

***Physaria pachyphylla* (Thick-leaf Bladderpod) in Montana and Wyoming:
Field Surveys and Status Assessment, 1983 to 2024**



Prepared For

**USDI BUREAU OF LAND MANAGEMENT
WYOMING & MONTANA/DAKOTAS STATE OFFICES**

Prepared By

MONTANA NATURAL HERITAGE PROGRAM & WYOMING NATURAL DIVERSITY DATABASE

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ABSTRACT

Physaria pachyphylla (Thick-leaf Bladderpod) was formally recognized as a species new to science in 2007 as described by Ben Grady and Steve O’Kane. The species occurs in the Pryor Mountain foothills and desert. At first it was only known from Montana, but subsequently documented nearby in Wyoming. *Physaria pachyphylla* is categorized as a Species of Concern by the Montana Natural Heritage Program (MTNHP) and Wyoming Natural Diversity Database (WYNDD), designated as Sensitive by the Montana/Dakotas Bureau of Land Management (MT/Dakotas BLM). In 2021, the US Fish and Wildlife Service (USFWS) received a petition to list *Physaria pachyphylla* and designate critical habitat under the Endangered Species Act (ESA).

For botanists working for the MT/Dakotas and Wyoming BLM, WYNDD, and MTNHP it was apparent that basic population, habitat, threat, and location information that is necessary for managing and assessing its status was very incomplete. Thus, a collaborative project, funded by the BLM, was developed. The MTNHP and WYNDD botany programs jointly conducted a study to assess the global status of *Physaria pachyphylla*. The project was carried out from 2023 to 2024 with the goals: 1) to compile all known information, including a review of literature, herbarium specimens, and observation records; 2) to conduct field inventories at previously known and newly reported locations and areas of potential habitat to validate presence/absence and collect population, threat, and habitat data; and 3) to more precisely map populations. Steve L. O’Kane, *Physaria* expert, was contracted to provide species determinations for voucher specimens collected from fieldwork. This project also incorporated *Physaria pachyphylla* data gained from an unrelated project conducted by WESTECH Environmental Services, Inc. involving abandoned uranium mines on BLM-administered lands in the Pryor Mountain foothills and desert.

This report presents a review of *Physaria pachyphylla* data from 1983 to 2024, and provides in-depth information on its identification, classification, distribution, reproductive biology, population ecology, habitat requirements, threats, and conservation needs. The earliest documented observation of *Physaria pachyphylla* was in 1983 in Montana. As of 2024, the locations of *Physaria pachyphylla* have been documented with 252 positive and 51 negative observations in Montana and Wyoming. Using NatureServe’s methods that employ a one-kilometer (1000 meters) separation distance *Physaria pachyphylla* is distributed across 10 global draft Element Occurrences (EO), or unique locations. Of the 10 global draft EOs, 6 are in Montana, 2 are in Wyoming, and 2 cross state boundaries. As mapped at a finer scale by MTNHP and WYNDD, *Physaria pachyphylla* is found in 25 Species Occurrences (SOs; equivalent to 8 draft EOs) in Montana and at 9 observation sites (OBS) in Wyoming (equivalent to 4 draft EOs). The 25 MTNHP SOs and 9 WYNDD OBS polygons cover approximately, 2,130 acres (8.6 square kilometers). Plants are not uniformly present throughout each discrete polygon and census surveys were not conducted. Based on the portions of these polygons surveyed, we estimate the global *Physaria pachyphylla* population to range between 7,837 to 12,493 individuals. Discrete occurrences range in size from 5 plants to over 1,300 individuals.

Our results confirm *Physaria pachyphylla* to be a local endemic of the Pryor Mountain foothills and desert that crosses the Montana and Wyoming state boundary. We estimate a global range that covers about 107 square miles (277 square kilometers). Populations span an elevational range from about 4,150 to 5,680 feet (1,265 to 1,732 meters) above sea level. It is highly restricted to specialized habitats occupying much less than 1% of its global range. Factors that contribute to putting populations at-risk of loss include non-native plants, ground-disturbing activities, and lack of federal protections governing the Pryor Foothill RNA/ACEC. Following this report, MTNHP and WYNDD will work collaboratively with NatureServe to conduct final EO mapping as part of the Global and Subnational rank review process.

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Before the 2023 field season, Steve O’Kane (University of Northern Iowa, emeritus) reviewed his field notes and helped MTNHP correct their mis-interpreted mapping of his herbarium specimens. After the 2023 and 2024 field seasons, he reviewed voucher specimens and photographs from MTNHP, WYNDD, and BLM staff and iNaturalist observers to make species determinations.

Jennifer Lyman (Rocky Mountain College in Billings, MT, retired) and Marian Lyman (Northern Rockies Research and Educational Services biologist) kindly provided plant phenology and moth visitation data, respectively, and *Physaria pachyphylla* photographs. Glenn Clifton contributed discussion on distinguishing characteristics and photographs, along with his species distribution information.

Ben Legler (Rocky Mountain Herbarium, University of Wyoming) imaged our 2023 voucher collections and provided them to O’Kane for making species determinations. Giovanni Bishop (University of Montana Herbarium) provided a high-definition photo of the 2020 Britton Spring, WY collection and manages the specimens that were critical to study prior to conducting fieldwork.

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Front Cover Photo Credits:

Upper Photograph: *Physaria pachyphylla* showing its thick, cupped, and densely pubescent basal leaves, racemes of 1-lobed fruits with styles that are less than twice the length of the fruit. Photo Credit: Steve O’Kane, 21 July 2005.

Lower Photograph: At the Wyoming/Montana border looking north at the foreground of *Physaria pachyphylla* habitat of ridge tops and slopes. In the background is Sykes Ridge, a local landmark. Photo Credit: Kenda Herman, 12 June 2023.

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I. INTRODUCTION

Physaria pachyphylla O’Kane & Grady (Thick-leaf Bladderpod) was formally recognized as a species new to science in 2007 based on fieldwork and subsequent reviews of herbarium specimens (Grady and O’Kane 2007). The 1998 type specimen (*O’Kane and Prather-O’Kane 4511*) was collected from the Gyp Spring area of the Pryor Mountain desert in Montana¹. The earliest documented specimen was collected in 1983, east of Crooked Creek in Montana and was re-determined in 2005 to be *Physaria pachyphylla*. Other specimens collected in the Pryor Mountain foothills and desert of Montana and Wyoming were later re-determined to be *Physaria pachyphylla* by authors Steve O’Kane and Ben Grady².

Known only from Montana and Wyoming, *Physaria pachyphylla* is categorized as a Species of Concern by the Montana Natural Heritage Program (MTNHP) and Wyoming Natural Diversity Database (WYNDD) and designated as Sensitive by the Montana/Dakotas Bureau of Land Management (MT/Dakotas BLM) (MTNHP 2024; WYNDD 2024; MT/Dakotas BLM 2020). In 2020 gypsum mining was proposed within the Pryor Foothills Research Natural Area (RNA)/Area of Critical Environmental Concern (ACEC) which has the largest *Physaria pachyphylla* population the Gyp Spring area (Federal Register 2022). Partially due to the mining threat, the Center for Biological Diversity filed a petition on May 17, 2021, to request listing of the species and critical habitat under the Endangered Species Act (ESA) (Center for Biological Diversity 2021). Subsequently, the U.S. Fish and Wildlife Service (USFWS; FWS) issued a 90-day finding that the petition presented substantial information indicating that listing of the species as an endangered or threatened species may be warranted (USDI FWS 2022).

Starting in 2020 MT/Dakotas BLM staff conducted surveys for *Physaria pachyphylla* in the proposed project area near Gyp Spring. It became apparent by botanists working for the MT/Dakotas BLM, Wyoming BLM, MTNHP, and WYNDD that information for the remaining vouchered locations was incomplete. Therefore, a more extensive study was needed to understand and verify the distribution and status of *Physaria pachyphylla*. In 2022, the WYNDD botanist conducted preliminary field surveys for *Physaria pachyphylla* in the Bighorn National Recreation Area, administered by the National Park Service (Heidel 2023). In 2023, a joint project between WYNDD and MTNHP was funded to assemble past information and conduct range-wide field inventories to verify presence/absence, collect population data, and incorporate survey results from other agencies and organizations on *Physaria pachyphylla*. Inventory work in 2023 was interrupted by road washouts that prevented access to target locations. In addition, five new locations were reported in 2023. Thus, an interim report was produced to convey progress on the original objectives, justify their expansion, and provide a reference for discussion with BLM state office staff. This final report is based on the interim report (Heidel et al. 2024), and compiles information from literature, herbarium specimens, and field studies from 1983 to 2024 to update the status and distribution of *Physaria pachyphylla*.

¹ Type (holotype) specimen at Gray Herbarium (GH). Digitized by Harvard University Herbaria & Libraries: https://kiki.huh.harvard.edu/databases/specimen_index.html

Isotype and other specimens at University of Montana Herbarium (MONTU). Digitized information at the Consortium of Pacific Northwest Herbaria: <https://www.pnwherbaria.org/>

² MONTU (non-digitized collection) and Rocky Mountain Herbarium (RM). RM digitized information at: <https://rmh.uwyo.edu/data/search.php>

II. METHODS

Bonnie Heidel, WYNDD Lead Botanist, and Andrea Pipp, MTNHP Program Botanist, jointly implemented the project, with WYNDD serving as the administrative lead. We coordinated with botanists from both the MT/Dakotas and Wyoming state offices for the Bureau of Land Management (BLM) and with staff from the Montana and Wyoming USFWS offices. The project involved a search for literature and herbarium specimen data, a review of records in agency and Natural Heritage Program (NHP) databases, consultation with experts, and field inventories.

This project also incorporated *Physaria pachyphylla* data gained from an unrelated project involving abandoned mines on BLM-administered lands in the Pryor Mountain foothills and desert. Here, the authors summarize their methods pertinent to the overall field surveys, data analysis, and status assessment of *Physaria pachyphylla*. Readers are encouraged to consult the *Pryor Mountains Botanical Survey Report* for the Bat Conservation International DOE-BLM Abandoned Mine Lands Safeguarding Project by WESTECH Environmental Service, Inc. (2024), hereafter WESTECH.

A. Literature, Voucher Collections, and Expert Consultation

The scientific publication describing *Physaria pachyphylla* was the primary reference used to identify diagnostic characteristics of the target and look-alike species, their habitat, including soils and geology, and location data (Grady and O’Kane 2007). Additional treatments were reviewed, including the Manual of Montana Vascular Plants (Lesica, Lavin, and Stickney 2022) and *Physaria* (O’Kane 2010) within the Brassicaceae in Flora of North America (FNA) by Al-Shehbaz (2010).

For this project, WYNDD contracted with Steve O’Kane, author of the *Physaria* treatment in FNA, and co-author of the publication recognizing *Physaria pachyphylla* as a new species (O’Kane 2010; Grady and O’Kane 2007). To assist botanists with plant surveys, O’Kane prepared a handout comparing the identification characteristics of *Physaria pachyphylla* and its closes look-alike *Physaria spatulata* (**Appendix A**). Natural Heritage Program botanists collected voucher specimens and photographs from the survey locations visited in 2023 and 2024. The 2023 specimens from both Montana and Wyoming were submitted to the Rocky Mountain Herbarium (RM) for accessioning and high-definition scanning. The 2024 specimens were sent directly to O’Kane for his review. O’Kane determined species identifications from the 2023 scanned images of the collections, 2024 voucher specimens, and photographs from both years. A selection of the 2024 voucher specimens were deposited at the University of Montana Herbarium (MONTU), with the remainder being retained at the MTNHP office.

B. Herbarium Specimens and Natural Heritage Program Data

Prior to this project, the majority of *Physaria pachyphylla* data in the MTNHP and WYNDD databases was based on herbarium specimen records. A smaller amount of NHP data came from field observations supported by specimens or photographs, but not officially accessioned by an herbarium. Prior to the 2023 fieldwork, herbarium data was queried from the Consortium of Pacific Northwest Herbaria (CPNWH) and RM Herbarium portals^{1,2}. In both NHP databases, Pipp and Heidel scrutinized the data and interpretations used to map the observations. O’Kane was consulted to review MTNHP’s spatial mapping of his specimens, which resulted in several being rectified. The resultant suite of locations mapped in the MTNHP and WYNDD database served as the starting point for field surveys in 2023 and 2024.

After the 2023 field season, MTNHP and WYNDD received additional reports of *Physaria pachyphylla* locations from Wyoming and MT/Dakotas BLM staff and iNaturalist users. At the end of the two-year project iNaturalist observations were scrutinized by MTNHP current and past botanists. Accepted iNaturalists observations were determined to be accurate to most-likely accurate and lacked large locational uncertainties and other mapping problems. Rejected iNaturalist observations had mapping problems that could not be resolved and were moved into the MTNHP deleted observation table. The

accepted observation, final Species Occurrence (SO), and draft Element Occurrence (EO) data and spatial mapping were incorporated into the MTNHP and WYNDD databases, accordingly. Species data in Montana can be obtained from MTNHP³. Species data in Wyoming can be obtained from WYNDD⁴.

C. MTNHP and WYNDD Field Inventories

For this project, field inventories were conducted by MTNHP and WYNDD botanists. In 2023, field surveys in Montana and Wyoming were conducted by Bonnie Heidel and Kenda Herman, MTNHP Botany Data Assistant, from June 11-15. From June 18-21, 2023, Heidel conducted additional surveys in Wyoming. On June 16th, Heidel led a 1-day field-based workshop in Montana. The workshop was attended by Kenda Herman and BLM staff. The purpose was to relay information on plant identification for the target and look-alike species, survey methods, and preliminary results from the initial week of surveys.

In 2024, Andrea Pipp and Kenda Herman conducted field surveys in Montana from June 10 to 15. Heidel conducted field surveys in Wyoming from June 22 to 24, and on July 17. On July 17, Heidel was accompanied by Wyoming BLM staff, Madison Clarke.

Known *Physaria pachyphylla* locations were projected onto digital imagery and downloaded onto tablets to help navigate to sites and interpret aerial photography signatures while in the field. Three additional layers were superimposed for navigation and orientation, including the USGS 7.5-minute topographic map boundaries, Public Land Survey Office township and section boundaries, and the BLM land management layer. All known sites were printed out at the scale of quarter-quads for ease of cross-reference to USGS topographic maps. Both aeriels and topographic maps were used as navigation tools along with BLM 1:100,000 surface management maps. Mapping of plants and other features was conducted by collecting waypoints on a Samsung Galaxy Tab Active3 tablet. The tablet was loaded with the OnX mapping app representing public lands and private ownership. Waypoints were also collected using Garmin Global Positioning System (GPS) units (Oregon 700 and 66s).

The primary tasks were to locate *Physaria pachyphylla* plants at sites documented by herbarium records, confirm the plant's identity, and expand surveys across similar habitat(s) in the landscape. The secondary tasks were to precisely map populations and characterize its habitat. Most Montana locations were mapped as a single isolated data point with low mapping precision. The Gyp Spring locations were mapped precisely with many overlapping points and polygons generated from GPS units. Areas were targeted for revisits in 2023 (**Figure 1**) and 2024 (**Figure 2**).

The vast majority of sites were surveyed by two people. At each visited site, surveys were expanded across similar habitat by multiple working hypotheses of what constituted suitable habitat. Given site-specific intersections of aspect, topography, and soil parent material, survey strategies varied from place to place. *Physaria pachyphylla* habitat was described as dry, barren, and calcareous (Grady and O'Kane 2007); therefore, the high reflectance of bare habitat shown on aerial imagery was a focal place to conduct surveys. Surveys routinely involved checking the most barren habitats of the area or, in some cases, the only barren habitat of the area. The generalized geology layer that transcended state boundaries had very little detail but served to represent the extent and orientation of major outcrop formations.

At each site, we oriented ourselves to the layout of *Physaria pachyphylla* suitable habitat and conducted a survey. Suitable habitat was traversed by walking widely spaced transects to estimate the number of plants and map the population's extent. Where suitable habitat occurred in broad bands, we walked

³ Montana Natural Heritage Program (MTNHP): <https://mtnhp.mt.gov/>

⁴ Wyoming Natural Diversity Database (WYNDD): <https://www.uwyo.edu/wyndd/index.html>

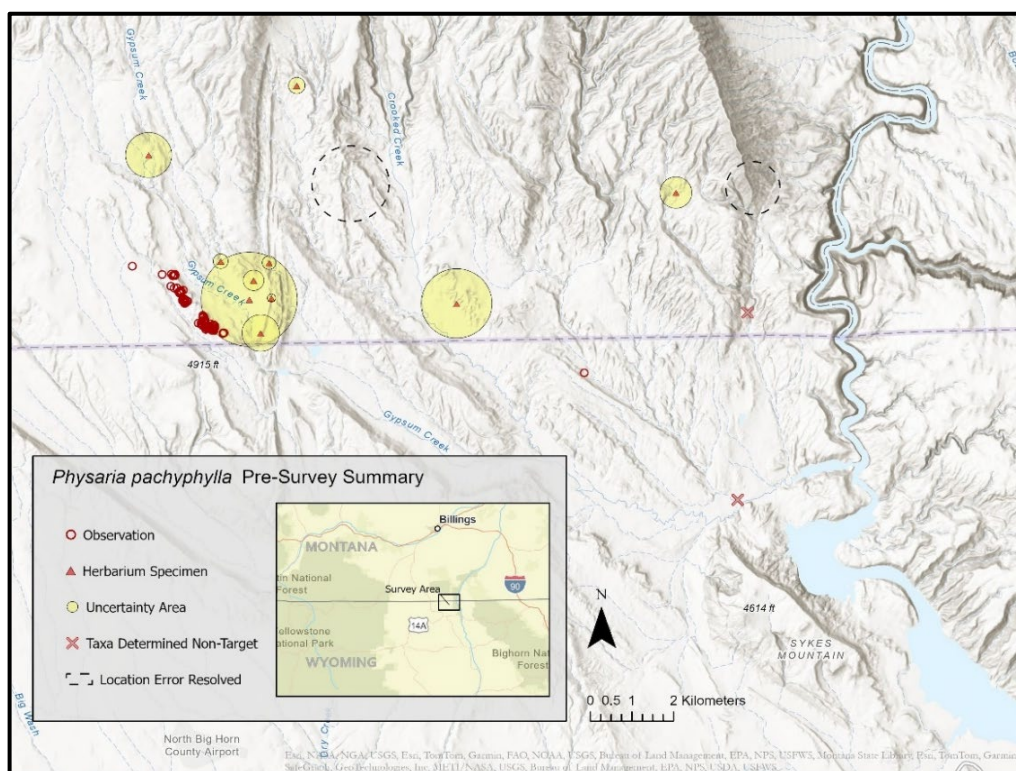


Figure 1. The distribution of *Physaria pachyphylla* prior to the 2023 field season. The observation and herbarium specimen locations were targets for field inventories and mapping in 2023.
Reprinted from the Interim Report (Heidel et al. 2024).

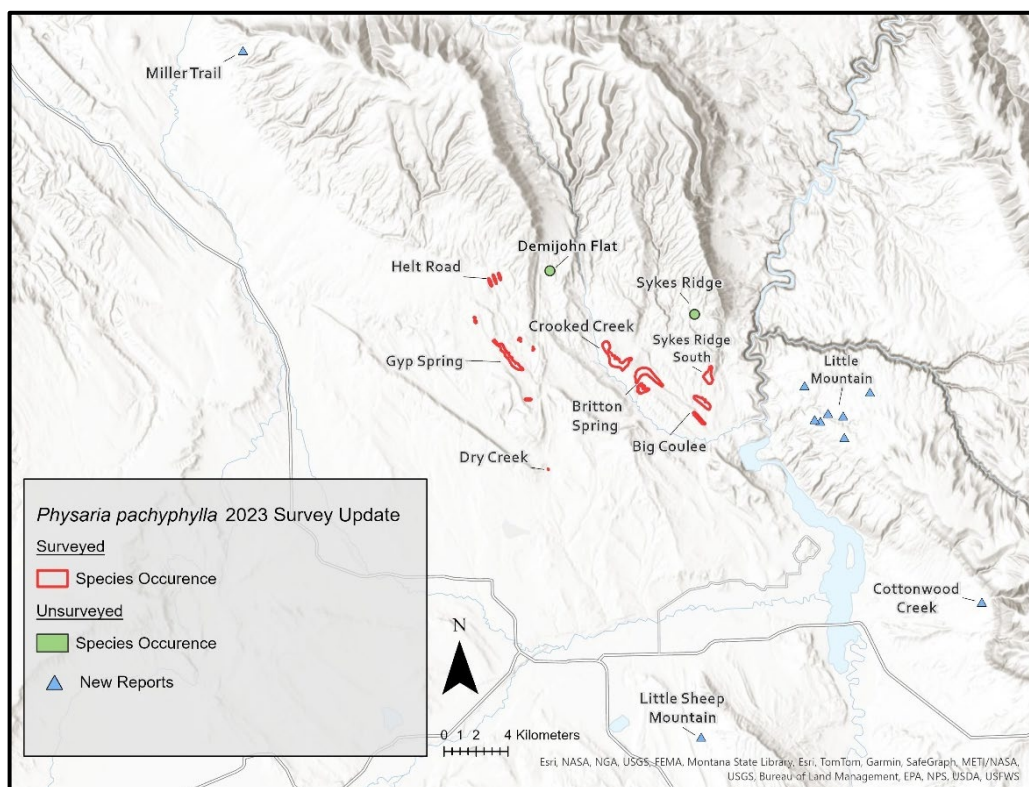


Figure 2. The revised distribution of *Physaria pachyphylla* prior to the 2024 field season. New reports and all unsurveyed and some surveyed Species Occurrences were targets for field inventories and mapping in 2024.
Reprinted from the Interim Report (Heidel et al. 2024).

separate parallel transects. Where the bands were narrow, we walked different segments of the habitat. We collected an initial tally of plants in each continuous habitat segment. Each plant in their field of view was counted while walking through continuous habitat segments. In low-density habitat, it was easy to count individual plants. In high-density habitat, the number of plants was estimated. To improve consistency, we calibrated with one another on the number of plants counted in various sized clustered at intervals during the survey. It proved to be an efficient use of time to estimate plant counts while surveying to find the extent of a population.

The cumulative count of plants found in the surveyed habitat was then extrapolated to the mapped habitat. For example, the master tally from a survey that covered close to 50% of potential suitable habitat would be multiplied by two to estimate a total plant count. Both the initial tallies and estimated coverage of potential habitat are uncertain, and each value provides an effective means to understand relative population sizes across the landscape. In almost all settings, whether dissected topography or level topography, the species' distribution was far more nuanced making it difficult to map localized or discrete populations. Voucher specimens representing typical plants and the range of variation were collected at each site. Likewise, photographs were taken of individual plants determined to be typical, different, or unidentifiable, and of variations in habitat conditions. Ultimately, the 2023 voucher specimens were accessioned and deposited at RM and some of the 2024 collections accessioned and deposited at MONTU with the remaining stored at the MTNHP office. Refer also to Section II, D.

D. WESTECH Environmental Services, Inc. Field Inventories

Relevant data and expertise were provided through timely collaboration on an unrelated project involving abandoned mines on BLM-administered lands. Surveys for *Physaria pachyphylla* and other BLM Sensitive plants were also carried out in 2024 by WESTECH Environmental Services, Inc. on behalf of Bat Conservation International (WESTECH 2024). Plant surveys were conducted by two WESTECH biologists with botanical expertise and LXM owner/botanist, Scott Mincemoyer, who is also a former MTNHP botanist. All consultants reviewed habitat requirements, plant phenology, and diagnostic characteristics for each Sensitive species. To assist in accurately identifying *Physaria pachyphylla* and its look-alike species, herbarium specimens and publications were studied, and a known location was revisited. Sites were visited from June 8-9 by WESTECH biologists when *Physaria* species were predominantly in flower and by all three surveyors from August 16-17 when *Physaria pachyphylla* plants were in fruit to senescing. Voucher specimens were collected in June by WESTECH consultants and deposited in their plant repository in Helena, Montana. Mincemoyer reviewed all WESTECH voucher specimens to determine their identification. Mincemoyer also studied the specimens collected by MTNHP that were annotated by O'Kane in 2024.

III. SPECIES INFORMATION AND FIELD INVENTORY RESULTS

A. Classification

In addition to the cited references below, information on the classification of *Physaria pachyphylla* also comes from Grady and O’Kane (2007) and O’Kane (2010).

1. Scientific Name: *Physaria pachyphylla* O’Kane & Grady
2. Synonyms: None
3. Common Name: Thick-leaf Bladderpod⁵, in reference to the basal leaves which are nearly 1 mm thick (Grady and O’Kane 2007).
4. Family: Brassicaceae
5. Size of Genus: The *Physaria* genus contains 106 species, with 88 in the Flora of North America, north of Mexico (O’Kane 2010). It includes members of what was once regarded as a separate genus, *Lesquerella*. The two genera were joined in order to produce a monophyletic and morphologically coherent treatment (Al-Shehbaz and O’Kane 2002). In Wyoming, there are 24 species of *Physaria*, with three having two varieties for a total of 27 unique taxa (Nelson and Legler 2023). In Montana, there are 17 *Physaria* species (Lesica, Lavin, and Stickney 2022).
6. Phylogenetic Relationships: Relationships among species of the *Physaria* genus have not been addressed in any genus-wide treatment. O’Kane (2010) stated “The genus is notable for its relatively large number of local, often endangered, and edaphically-determine (usually calciphilic) species”. For example, *Physaria lesicii* is a narrow endemic that is known only from Montana and occurs at higher elevations than *Physaria pachyphylla* in the Pryor Mountains.

B. Present Legal and Other Formal Status

1. National Legal Status: On March 11, 2021, a petition to list *Physaria pachyphylla* and designate critical habitat under the ESA was submitted to the USFWS (Center for Biological Conservation 2021). The subsequent 90-day finding found substantial scientific or commercial information indicating that listing as a threatened or endangered species may be warranted (USDI FWS 2022; 87 FR 7079). In August 2023, the USFWS national office sent a request for current information on this plant and other species on the National Listing Workplan. The USFWS initiated both a 12-month review and a Species Status Assessment (SSA) in 2024 (USDI FWS 2024a). The review and SSA are being co-led by the Wyoming and Montana Ecological Services offices.

Physaria pachyphylla was designated as Sensitive by the MT/Dakotas BLM (2020). The Wyoming BLM state office had not considered this species as Sensitive because confirmation in the state only arrived at the time of petitioning.

The MTNHP and WYNDD botanists have assisted the processes conducted by the USFWS and the BLM in many ways. In February 2024, an interim report (Heidel et al. 2024) on this project was prepared by the NHPs for the Wyoming and MT/Dakota BLM state offices and shared with both USFWS offices. On August 26, 2024, a joint meeting attended by MTNHP and WYNDD botanists

⁵ The common name was given as Thick-leaf Bladderpod, and spelled with a hyphen, in the publication by Grady and O’Kane (2007). Some organizations spell the common name without the hyphen.

and USFWS and BLM staff from both states allowed Pipp and Heidel to provide an update from the 2024 field season on the plant's population sizes, distribution, and threats (USDI FWS 2024b). From September 24-26, the Montana and Wyoming USFWS offices jointly hosted a *Thick-leaf Bladderpod (Physaria pachyphylla) Species Status Assessment Rapid Prototyping Workshop* (USDI FWS 2024c). The meeting consisted of in-person with virtual attendance capabilities and field visit components. The in-person/virtual component was attended by MTNHP (Herman), WYNDD (Heidel), LXM Consulting (Mincemoyer), O'Kane, many USFWS and BLM staff from both states, and members from the Northern Rockies Research and Educational Services. Discussions on *Physaria pachyphylla*'s life history traits, identification, genetics, distribution, population sizes, threats, and other topics were used by USFWS staff to complete the SSA process. The USFWS initiated the 12-month review process for *Physaria pachyphylla* and plans to make a listing determination in 2026, that will be announced in the Federal Register (USFWS 2024a). To inform the listing decision, the USFWS Wyoming and Montana offices are conducting a Species Status Assessment (SSA); a draft SSA Report is anticipated in winter 2025 with peer-review in late spring 2025 (Lassiter personal communication).

2. Global (G-) Heritage Rank: G2G3. The global rank was prepared in 2015 based on the known Species Occurrences as defined by MTNHP and low threats at that time. Upon completion of this project and report, the G-rank will be reviewed and updated.
3. State Legal Status: Plants do not have legal status in Montana or Wyoming.
4. Subnational (S-) State Heritage Ranks: S2S3 in Montana (MTNHP 2012); S1 in Wyoming. These S-ranks will be re-evaluated following the completion of this project.

C. Species Description

1. General Non-Technical Description (Grady and O'Kane 2007; O'Kane 2010 and 2023): *Physaria pachyphylla* is a perennial forb with few to many prostrate, decumbent, or ascending stems of 2-15 cm tall that arise from an unbranched caudex (**Photos 1 to 12**). The basal leaves are leathery, usually 1 mm thick, covered by silver-gray 5-rayed hairs, oblanceolate to orbiculate or spatulate, usually 1.2-2 cm long, tapering to a petiole, with entire margins and often slightly cupped. The inflorescence is a cluster of yellow flowers with 4 sepals and 4 petals 5-6(8) mm long. Fruits are globose but usually with a pointed tip, 3-6 mm long, covered by closely-appressed hairs and borne on a stalk 5-7 mm long that is curved upward and less than twice the length of the fruit. Fruits are densely clustered in the inflorescence and subumbellate. Ovules are 8 per locule.
2. Technical Description (Grady and O'Kane 2007; O'Kane 2023): Perennials; caudex usually simple, rarely branched, moderate to large in size; loosely mounded from a strong basal rosette of leaves; densely pubescent, the leaves, therefore, silver or silver-pale green, trichomes sessile, 5-rayed, rays bifurcate, slightly fused near base of main rays, tuberculate throughout, less over umbo (**Photos 1 to 12**). Stems several from base, decumbent to prostrate, well-exserted beyond basal leaves, 0.2–0.5 dm. Basal leaves: petiole differentiated from blade; blade slightly cupped, leathery, nearly 1 mm thick, oblanceolate to orbicular, 1.2–2 cm, margins entire, apex acute. Cauline leaves: blade spatulate. Racemes dense, subumbellate, exceeding the leaves or sometimes $\pm$ equal to them. Fruiting pedicels ascending, curved, 5–7 mm, less than 2 times longer than fruits. Flowers: sepals pale yellow, elliptic to oblong, 3.5–4.0 mm, median pair somewhat thickened apically, cucullate; petals ligulate, 5–6 mm. Fruits globose or ellipsoid, slightly inflated with slight apical, latiseptate compression, 3–6 mm; valves densely pubescent, trichomes closely appressed; ovules 8 per ovary; style 1–3 mm, shorter than mature fruit. Seeds plump.

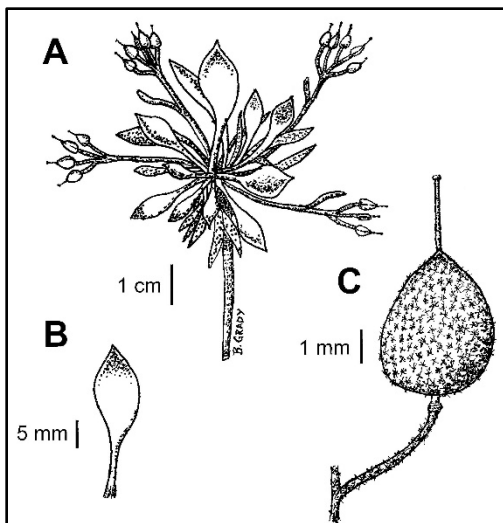


Photo 1. *Physaria pachyphylla*. Drawn from holotype, O’Kane & O’Kane 4511, GH (Grady & O’Kane 2007). A. Pressed plant. B. Basal leaf. C. Silicle and fruiting pedicel.



Photo 2. *Physaria pachyphylla*. Typical form. Britton Spring site, WY. 11 June 2023. Photo Credit: Bonnie Heidel.



Photo 3. *Physaria pachyphylla*. Compact form. Gyp Spring area, MT. 13 June 2023. Photo Credit: Bonnie Heidel



Photo 4. Early fruiting, late flowering, and inconspicuous basal leaves. Crooked Creek area, MT. 12 June 2023. Photo Credit: Kenda Herman



Photo 5. *Physaria pachyphylla*. Peak fruiting, late flowering, elongated inflorescence, and conspicuous basal leaves. MT. 12 June 2016. Photo Credit: Peter Lesica



Photo 6. *Physaria pachyphylla*. Peak fruiting and conspicuous basal leaves. SO-ID 5003371, MT. 12 June 2024. Photo Credit: Andrea Pipp



Photo 7. *Physaria pachyphylla*. Basal leaves may begin withering as flowering and fruiting proceed. Gyp Spring area. Photo Credit: Glenn Clifton



Photo 8. *Physaria pachyphylla*. Plants occasionally grew rooted in the mat or litter of other plant species. Britton Spring site, WY. 11 June 2023. Photo Credit: Kenda Herman



Photo 9. *Physaria pachyphylla*. Plants did not show disease or herbivory. Presence of galls were rare. Gyp Spring area, MT. 15 June 2023. Photo Credit: Kenda Herman



Photo 10. *Physaria pachyphylla*. Compact. Flowering later than most individuals. Big Coulee site, WY. 21 June 2023. Photo Credit: Bonnie Heidel



Photo 11. *Physaria pachyphylla*. Simple caudex of moderate to large size and thick basal leaves. Britton Spring site, WY. basal leaves. 25 June 2020. Photo Credit: Jennifer Jones



Photo 12. *Physaria pachyphylla*. Senesced fruits and conspicuous basal leaves. Gyp Spring area, MT. 20 September 2020. Photo Credit: Laura Holloway

3. Local Field Characters: A handout for identifying *Physaria pachyphylla* and its distinction from *P. spatulata* was prepared by Steve O’Kane in 2023 and distributed at the workshop (**Appendix A**). In it, he emphasized that the fruiting pedicels of *Physaria pachyphylla* are gently curved upward; pedicels are less than two times longer than fruits; basal leaves (when fresh) are nearly 1 mm thick with blades that are usually cupped; and the fruits have a style 1–3 mm long, shorter than the mature fruit; and densely clustered in the inflorescence. Lesica, Lavin, and Stickney (2022) highlighted the difference between *Physaria pachyphylla* and *P. spatulata* emphasizing the difference of pedicel characteristics, stating that the latter species has sigmoid rather than up-curved pedicels.

Almost all plants surveyed by MTNHP and WYNDD botanists in 2023 and 2024 were in fruit. If any flowering plants were also present, a flowering plant was included with fruiting individuals in the collection.

4. Hybridization: Among the 11 specimens collected as vouchers in 2023, O’Kane noted that 3 specimens may represent hybrids or introgression between *Physaria pachyphylla* and *P. spatulata*. Among the 22 specimens collected as vouchers in 2024, O’Kane remarked that one collection represented possible introgression between *Physaria pachyphylla* and *Physaria spatulata*. At least two specimens came from occurrences where both species were represented.
5. Similar Species: *Physaria spatulata* overlaps with *Physaria pachyphylla* in both identifiable characteristics and distribution (**Appendix A**). *Physaria spatulata* has a weakly formed or nearly absent basal rosette of leaves, that are sparsely to moderately pubescent making them appear green; a fruiting pedicel that is strongly sigmoid at maturity and at least twice the length of the fruit; and a style that is usually equal in length to the fruit or greater.

Physaria spatulata has the greatest distributional overlap with *Physaria pachyphylla* (Grady and O’Kane 2007). Fieldwork conducted by botanists working for MTNHP, WYNDD, and WESTECH found that while sub-populations of *Physaria pachyphylla* and *P. spatulata* are usually separated, they can co-occur. Hence, many of the *Physaria pachyphylla* occurrences also contain pockets of land where *P. spatulata* is found or suspected.

Other species that resemble *Physaria pachyphylla* do not overlap in their distributions, except for *Physaria curvipes* which is found at higher elevations the Pryor Mountains of Big Horn County, Montana and in the Big Horn Mountains of south-central Wyoming. These *Physaria* species include: a) *P. curvipes* which has long styles and grows at higher elevations in montane to subalpine habitats in Montana, b) *P. subumbellata* which has basal leaves that are diamond-shaped; c) *P. montana* which has basal leaves that are suborbicular or obovate to elliptic; and d) *P. prostrata* which has prostrate or decumbent stems.

D. Geographical Distribution

1. **Range:** Prior to 2023, the range of *Physaria pachyphylla* included scattered occurrences in the Pryor Mountain foothills and desert of Montana and Wyoming (see **Section II-Methods, Figures 1 and 2**). Based on the 2023 to 2024 field inventories conducted by MTNHP, WYNDD, and WESTECH, the range of *Physaria pachyphylla* expanded in Montana and Wyoming. The species is found just west of Gypsum Creek eastward to Big Horn Canyon National Recreational Area in Montana and from the south side of the Pryor Mountains in Montana southward to County Road 7 ½ and Gypsum Creek Road in Wyoming (**Figure 3**). The estimated global range covers about 107 square miles (277 square kilometers) (**Figure 3**).

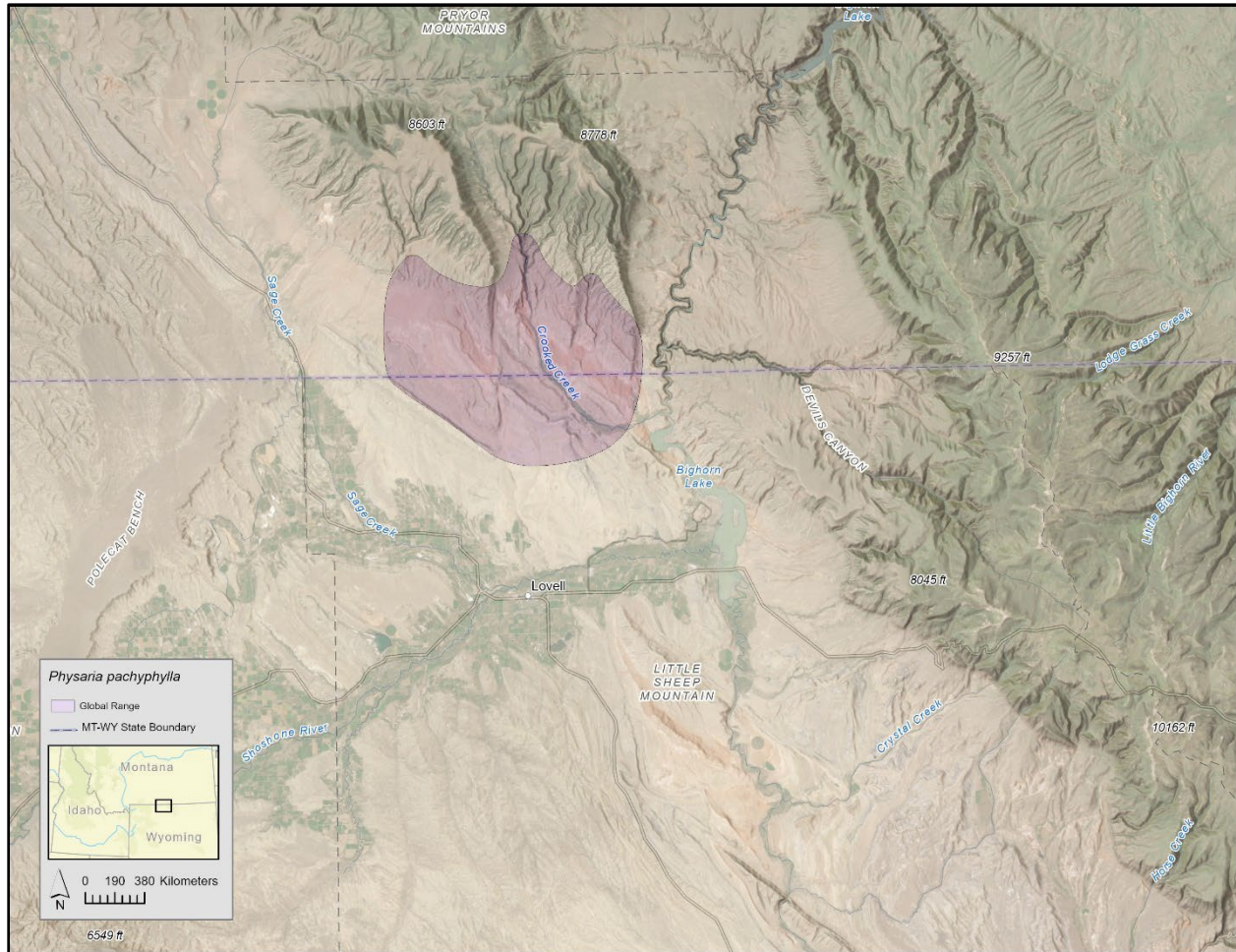


Figure 3. The global range of *Physaria pachyphylla* based on observation data from 1983 to 2024.

2. **Extant Sites:** This project has sought and compiled all known data on *Physaria pachyphylla* from 1983 through 2024, centralizing it in the MTNHP and WYNDD databases. The earliest documented occurrence is from 1983 at a location between Crooked Creek and Crooked Creek Road in Montana. As of 2024, the locations of *Physaria pachyphylla* have been documented with 252 positive and 51 negative observations⁶ in Montana⁷ and Wyoming⁸, as databased by the MTNHP (**Figure 4**). Of the 252 observation points, 48 are supported by plant specimens deposited at the RM and MONTU herbaria and WESTECH and MTNHP plant repositories⁹ (**Table 1**). The 51 negative observations include the five locations where *Physaria pachyphylla* was reported in 2023, revisited to collect plant specimens or photographs in 2024, and determined by O’Kane to be *P. spatulata* (see Section III, D, #6) (**Figure 4**). Collectively, the dataset on positive observations confirms that *Physaria pachyphylla* is a local endemic of the Pryor Mountain foothills and desert covering Montana and Wyoming. Plants have been found at elevations ranging from about 4,150 to 5,680 feet above sea level.

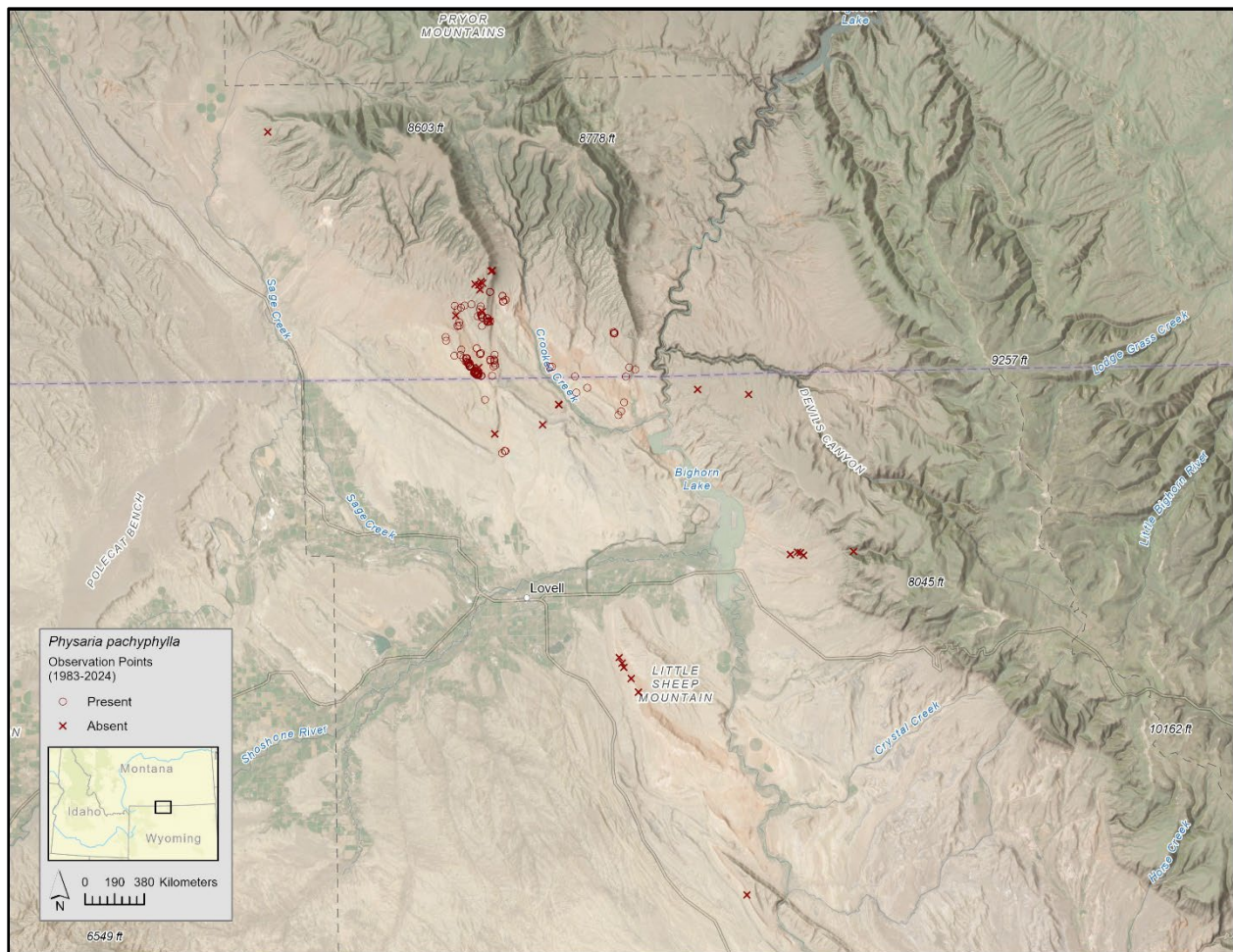


Figure 4. Locations of positive and negative observation points for *Physaria pachyphylla* from 1983 to 2024.

⁶ MTNHP defines an observation as “A species is found in a defined geographical area on (a) specified date(s) by (a) specified person(s).” Each observation point reflects time as much as it reflects location.

⁷ Digital data for Montana is available from MTNHP at: <https://mtnhp.mt.gov/requests/>

⁸ Digital data for Wyoming is available from WYNDD Data Explorer Portal at: <https://wyndd.org/portal/login>

⁹ Pending accession, specimens at RM and MONTU are accessible through the online RM and Consortium of Pacific Northwest Herbaria portals. Specimens at WESTECH and MTNHP may be available upon request.

Table 1. Crosswalk of *Physaria pachyphylla* digital observation and plant specimen data as displayed in the Montana Natural Heritage Program botany database.

STATE	GENERAL PLACE NAME	SO-ID ¹	OBS-ID ²	PLANT COLLECTIONS ³	TRS ⁴
MT	Gyp Spring area	5002329	8510	O'Kane, S.L. (7920) and B.A. Grady. 2005. ISTC, MO.	009S027E033
			539213	Lesica, P. (5368). 1991. MONTU 115276.	009S027E028
			539219	Evert, E.F. (18961). 1990. RM 618968.	009S027E033
			2007551	Lesica, P. (11888), 2020. MONTU 166755.	009S027E033
			2373294	Herman, K. (2024-002a-c). 2024. MTNHP Botany Office. Determined by S. O'Kane, July 8, 2024.	009S027E033
			2373295	Pipp, A. (2024-008). 2024. MTNHP Botany Office. Determined by S. O'Kane, July 8, 2024.	009S027E033
			2373296	Pipp, A. (2024-007a). 2024. MTNHP Botany Office. Determined by S. O'Kane, July 8, 2024.	009S027E033
			2307055	Heidel, B. (5200) and K. Herman. 2023. RM	009S027E033
MT	Gyp Spring area (Type)	5003313	8509	O'Kane, S. (4511) and A. Prather-O'Kane. 1998. Holotype, GH; isotypes, BRY. COLO 520199. ISTC. MO. NY. RM 797390. MONTU 132200.	009S027E033
MT	Crooked Creek / Britton Spring region	5003314	8508	Lesica, P. (2608). 1983. MONTU 092976. Originally Identified as <i>Lesquerella alpina</i> . Determined to be <i>P. pachyphylla</i> by Grady, March 2005.	009S027E036
			2307052	Heidel, B. (5198a, 5198b, 5198c) and K. Herman. 2023. RM.	009S027E036
WY	Crooked Creek / Britton Spring region	OBS in WY	2307051	Heidel, B. (5197) and K. Herman. 2023. RM	009S028E034; 058N095W031
			2307060	Heidel, B. (5207) and K. Wahl. 2023. RM	009S028E034; 058N095W031
			2375188	Jones, J. 2020. MONTU. Archived, but not pressed or digitized.	
MT	Sykes Ridge, south terminus	5003315	539210	Heidel, B. (1731). 1998. MONTU 123894.	009S028E034
			2307058	Heidel, B. (5203). 2023. RM	009S028E034; 058N095W022
WY	Sykes Ridge, south terminus	OBS in WY	2307063	Heidel, B. (5204). 2023. RM	009S028E034
MT	Helt Road, south of	5003319	2007550	Lesica, P. (11304). 2015. MONTU 162631	009S027E029
MT	Gyp Spring Road	5003320	2307054	Heidel, B. (5199) and K. Herman. 2023. RM	009S027E030
MT	Helt Road, north	5003321	2307111	Heidel, B. (5201) and K. Herman. 2023. RM	009S027E018

Table 1 (continued). Crosswalk of *Physaria pachyphylla* digital observation and plant specimen data as displayed in the Montana Natural Heritage Program botany database.

STATE	GENERAL PLACE NAME	SO-ID ¹	OBS-ID ²	PLANT COLLECTIONS ³	TRS ⁴
MT	Sykes Ridge	5003370	8512	O'Kane, S. (7925) and B. Grady. 2005. RM 797386.	009S028E021
			2375307	Herman, K. (2024-001). 2024. 3 specimens at MONTU, pending accession. 2 specimens at MTNHP Botany Office. All determined by S. O'Kane, July 8, 2024.	009S028E021
MT	Gypsum Creek	5003371	539216	Lesica, P. (5411). 1991. MONTU 115156	009S027E019
			2373300	Pipp, A. (2024-005). 2024. MONTU, pending accession. Determined by S. O'Kane as <i>Physaria pachyphylla</i> with possible introgression from <i>P. spatulata</i> .	009S027E019
MT	Demijohn Flat, west of	5003372	8511	O'Kane, S. (7921) and B.A. Grady. 2005. GH, ISTC, MO, RM 797389.	009S027E016
			2373297	Pipp, A. (2024-010c). 2024. MONTU, pending accession. Determined by S. O'Kane, July 8, 2024.	009S027E009
			2373298	Pipp, A. (2024-010b). 2024. MONTU, pending accession. Determined by S. O'Kane, July 8, 2024.	009S027E009
			2373299	Pipp, A. (2024-010a). 2024. MONTU, pending accession. Determined by S. O'Kane, July 8, 2024.	009S027E009
			2375305	Herman, K. (2024-005). 2024. 4 specimens at MONTU, pending accession. 2 specimens at MTNHP Botany Office. All specimens determined by S. O'Kane, July 8, 2024.	009S027E015
MT	Swamp Frog Mine, south	5003373	2374158	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E020
			2374159	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E020
			2374160	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E020
MT	Swamp Frog Mine, north	5003374	2374161	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
			2374162	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
			2374163	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017

Table 1 (continued). Crosswalk of *Physaria pachyphylla* digital observation and plant specimen data as displayed in the Montana Natural Heritage Program botany database.

STATE	GENERAL PLACE NAME	SO-ID ¹	OBS-ID ²	PLANT COLLECTIONS ³	TRS ⁴
MT	-- CONTINUED-- Swamp Frog Mine, north	5003374	2374164	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
			2374165	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
			2374166	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
			2374182	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E017
MT	Snail 2 Mine	5003375	2374168	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E009
			2374169	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E009
			2374170	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E009
			2374171	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E009
MT	Swamp Frog 2 Mine, north	5003376	2374179	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E021
			2374173	Beaver, J. (s.n.). 2024. WESTECH Plant Repository. Identification verified by S. Mincemoyer on 8/16/2024.	009S027E021
WY	Big Coulee in WY	OBS in WY	2307057	Heidel, B. (5202) and K. Herman. 2023. RM	058N095W027
WY	Dry Creek (northern) or Gyp Spring area (southern) in WY	OBS in WY	2307048	Heidel, B. (5209) and K. Wahl. 2023. RM	
WY	Dry Creek in WY	OBS in WY	2307061	Heidel, B. (5208) and K. Wahl. 2023. RM	057N096W003; 058N096W028

¹ MTNHP assigns each SO with a unique identifier (SO-ID). Use Appendix B to crosswalk SO-ID with SO location.

² MTNHP assigns each observation with a unique identifier (OBS-ID). Each SO is supported by a minimum of one observation.

³ Herbarium Acronyms: GH = Gray's Herbarium; BRY = Brigham Young University; COLO = University of Colorado Boulder; ISTC = University of Northern Iowa; MO = University of Missouri; NY = New York Botanical Garden; RM = Rocky Mountain; MONTU = University of Montana

⁴ TRS = Township, Range, Section where the observation was documented.

Collectively, the dataset of positive field-based observations are mapped with habitat into discrete polygons called Element Occurrences (EOs) by NatureServe, Species Occurrences (SO) by MTNHP, or Observations by WYNND¹⁰. Regardless of the terminology, these discrete polygons are based on at least one direct field-based observation supported by photographs and/or plant specimens^{6, 7, 8, 9, 10}. NatureServe uses the EO concept to standardize the number of unique locations across states and countries where the plant species has been documented (NatureServe 2002). Using NatureServe's methods that employ a one-kilometer (1000 meters) separation distance¹¹, it is estimated that *Physaria pachyphylla* is found in 10 global draft EOs¹² (**Figure 5**). Of the draft 10 EOs, 6 are entirely in Montana, 2 are entirely in Wyoming, and 2 cross state boundaries¹². The MTNHP uses the SO concept to map discrete areas where the species has been documented at a finer scale than an EO while also retaining biological and conservation merit¹⁰. In Montana *Physaria pachyphylla* is found in 25 SOs, which is equivalent to 8 draft EOs (**Figure 5**; **Figures B1a-c in Appendix B**) (MTNHP 2025). In Wyoming, *Physaria pachyphylla* is found at 9 sites / observations, which is equivalent to 4 draft EOs (**Figure 5**; **Figures B1c-d in Appendix B**).

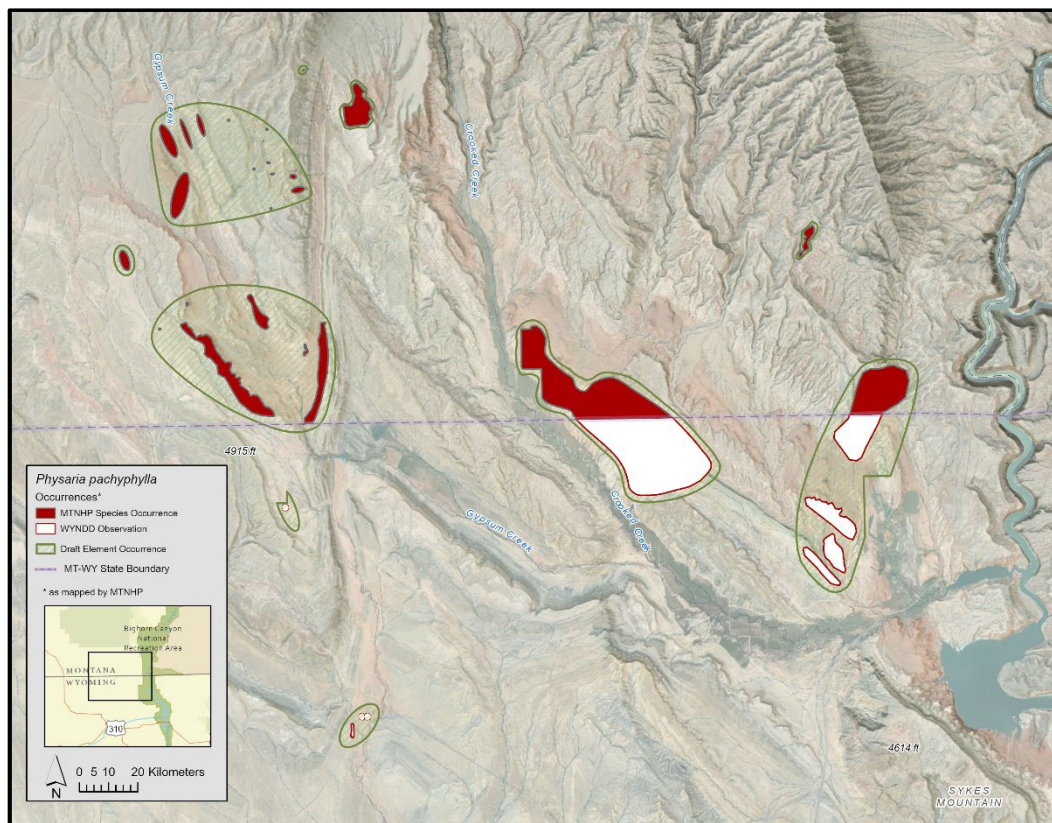


Figure 5. MTNHP Species Occurrences, WYNDD observations, and draft global Element Occurrences for *Physaria pachyphylla* based on observation data from 1983 to 2024.

¹⁰ Element Occurrence (EO): an area of land or water where a species has been documented and may include known habitat. In general, EOs are separated by at least 1 kilometer for terrestrial species. MTNHP Species Occurrence (SO): an area where a Species of Concern plant and its known habitat have been documented. In comparison to EOs, SOs are separated at a finer scale and retain conservation and biological merit. WYNDD has discontinued the use of an EO concept. WYNDD uses the term “observation” as to be equivalent to the MTNHP SO.

¹¹ Separation distance: The amount of intervening area between documented locations/habitat of a species that determines if those locations/habitats should be grouped as part of the same (complex) EO or be considered as discrete EOs.

¹² NatureServe, MTNHP, and WYNDD will conduct final EO mapping as part of the Global and Subnational rank review process.

3. Historical Sites: No historical sites. All known sites are occupied with *Physaria pachyphylla*.
4. Unverified/Undocumented Reports: There are no unverified or undocumented reports of *Physaria pachyphylla*.
5. Sites Where Present Status Is Not Known: There are no *Physaria pachyphylla* sites where the present status remains unknown.
6. Reported Sites Where Species Was Re-determined As False: *Physaria pachyphylla* was reported at several locations in 2023 based on photographs of flowering plants. These sites were revisited in 2024 and voucher specimens and photographs were sent to O’Kane for expert determination (**Figure 4**). The following locations were determined to have *Physaria spatulata*:
 - *Miller Trail, MT*: The northern-most report was found on a BLM-AIM plot in 2023. MTNHP botanists surveyed, photographed plants, and collected voucher specimens along about one mile of habitat along both sides of Miller Trail and at the AIM plot location in 2024.
 - *Mouth of Cottonwood Canyon, Big Basin Mountains, WY*
 - *Little Mountain, Big Horn Mountains, WY*
 - *Sheep Mountain, Big Horn Basin, WY*
 - *Little Sheep Mountain, Big Horn Basin, WY*

E. Habitat

1. Associated Vegetation: *Physaria pachyphylla* occupies sparsely-vegetated habitat with mainly low-growing perennial forbs and low bunchgrass cover. LANDFIRE mapping uses predictive landscape models based on extensive field-referenced data to describe the existing vegetation type (Ecological System), canopy cover, and vegetation height (La Puma, 2023). *Physaria pachyphylla* locations were superimposed upon the LANDFIRE map to determine the association with the Existing Vegetation type-Ecological Systems:
 - Inter-Mountain Basins Cliff and Canyon
 - Inter-Mountain Basins Shale Badland
 - Inter-Mountain Basins Mat Saltbush Shrubland
 - Inter-Mountain Basins Big Sagebrush Shrubland
 - Inter-Mountain Basins Mat Saltbush Shrubland
 - Northern Rocky Mountains lower montane-foothills-valley grassland

Most locations were associated with distinct, exposed bare rock outcrops, but much of the Helt Road population was on nearly-level ground and in relatively bare areas within well-established sagebrush steppe dominated by *Artemisia nova* and *A. tridentata* spp. *wyomingensis*. The range of vegetation and other habitat conditions were photographed (**Photos 13-18**).

2. Frequently Associated Species: Associated plant species are either consistently (high fidelity), or occasionally present with the to only present in marginal habitat (low fidelity) with *Physaria pachyphylla* (**Table 2**).



Photo 13. *Physaria pachyphylla* habitat showing broad bands at Gyp Spring, SO-ID 5002328, MT. South end, looking north. 13 June 2023. Photo Credit: Bonnie Heidel



Photo 14. *Physaria pachyphylla* habitat showing narrow band at Gyp Spring, SO-ID 5002328, MT. North end, looking south. On photo left is Gypsum Creek and another low ridge. 14 June 2023. Photo Credit: Bonnie Heidel



Photo 15. *Physaria pachyphylla* habitat at Crooked Creek, SO-ID 5003314, MT showing dissected land and ridgetops. 12 June 2023. Photo Credit: Kenda Herman



Photo 16. *Physaria pachyphylla* habitat where O'Kane collected the holotype specimen in 1998, retains a viable population today. SO-ID 5003313, MT 11 June 2024. Photo Credit: Andrea Pipp



Photo 17. *Physaria pachyphylla* habitat at Helt Road, MT. Relatively bare patches in well-vegetated habitat. 15 June 2023. Photo Credit: Bonnie Heidel



Photo 18. *Physaria pachyphylla* habitat in the foothills of Sykes Ridge. 19 June 2023. Photo Credit: Bonnie Heidel

Table 2. Vascular plant species associated with *Physaria pachyphylla*.

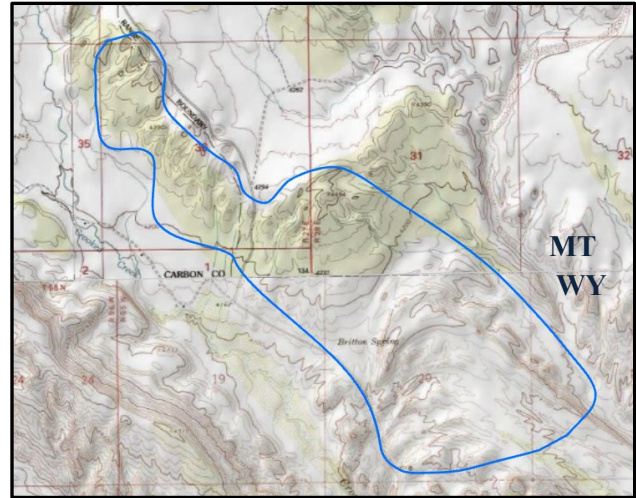
Scientific Name	Common Name	High Fidelity	Low Fidelity	Comment
<i>Achnatherum hymenoides</i>	Indian Ricegrass		X	particularly in sandier areas
<i>Aristida purpurea</i> var. <i>fendleriana</i>	Purple Three-Awn Grass	X		particularly in Pryor Mountain Wild Horse Range
<i>Astragalus hyalinus</i>	Summer Milkvetch		X	
<i>Astragalus spatulatus</i>	Tufted Milkvetch		X	
<i>Atriplex canescens</i>	Fourwing Saltbush		X	
<i>Elymus spicatus</i>	Bluebunch Wheatgrass	X		
<i>Cercocarpus ledifolius</i>	Mountain Mahogany		X	particularly in Pryor Foothills
<i>Cryptantha cana</i>	Mountain Cryptantha	X		
<i>Eremogone hookeri</i>	Hooker's Desert Sandwort	X		
<i>Eriogonum brevicaulis</i> var. <i>canum</i>	Rabbit Buckwheat	X		
<i>Gutierrezia sarothrae</i>	Broom Snakeweed		X	
<i>Hesperostipa comata</i>	Needle-And-Thread		X	particularly on sites with soil development
<i>Hymenoxys richardsonii</i>	Colorado Rubberweed	X		
<i>Juniperus osteosperma</i>	Utah Juniper		X	particularly in Pryor Foothills
<i>Paronychia sessiliflora</i>	Creeping Nailwort		X	
<i>Phlox hoodii</i>	Spiny Phlox	X		
<i>Phlox muscoides</i>	Moss Phlox	X		
<i>Pinus flexilis</i>	Limber Pine		X	particularly in Pryor Foothills
<i>Platyschukria integrifolia</i>	Basin Daisy		X	
<i>Sphaeromeria capitata</i>	Rock-tansy		X	particularly in Pryor Foothills
<i>Stenotus acaulis</i>	Stemless Mock Goldenweed	X		
<i>Tetraneuris acaulis</i>	Stemless Four-Nerve Daisy	X		
<i>Xanthisma grindelioides</i>	Rayless Tansyaster	X		

3. **Topography and Geology:** *Physaria pachyphylla* grows in exposed settings, often situated on prominent landforms such as ridge tops and rims, butte shoulders, and rocky escarpment breaks flanking the Pryor Mountains (**Photos 13-16, 18**). Plants also grow on toe slopes and low mounds in valley settings or in open terrain (**Photo 17**). They are at basin and foothill elevations within the Big Pryor and Southeast Pryor structural fault blocks, which have outcrops in an accordion-like pattern that follow anticlines (**Figures 6a-d**).

The distribution of *Physaria pachyphylla* overlaps with Mesozoic marine sedimentary deposits. They include the Gypsum Spring Formation (Jurassic); Chugwater Formation (Triassic); and Goose Egg Formation (Permian) as mapped for the Bighorn Basin in Wyoming (Marks personal communication 2023). There is coarser statewide geology mapping for Montana and for Wyoming with some differences between formation name and boundaries between states. The Wyoming state reference (Love and Christianson 1985) shows occupied habitat as mainly on two formations: the Cloverly and Morrison Formations, and the edge of the Chugwater Formation (Love and Christianson 1985). These heterogeneous deposits include interbedded layers. The Cloverly has



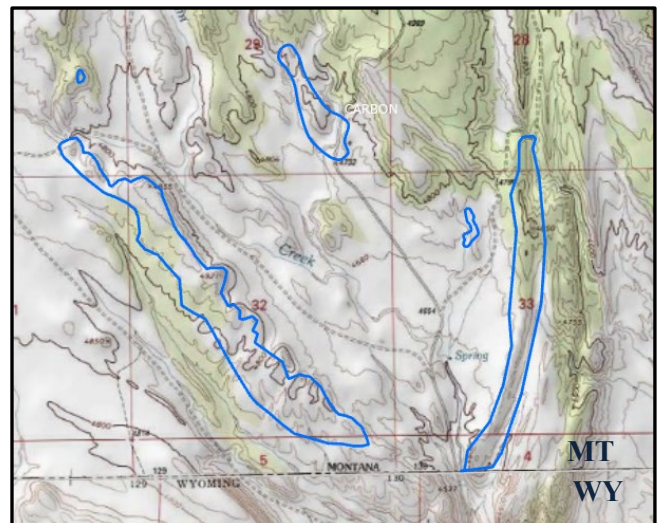
(a) Crooked Creek / Britton Spring SO



(b) Crooked Creek / Britton Spring SO



(c) SOs in Gyp Spring area.



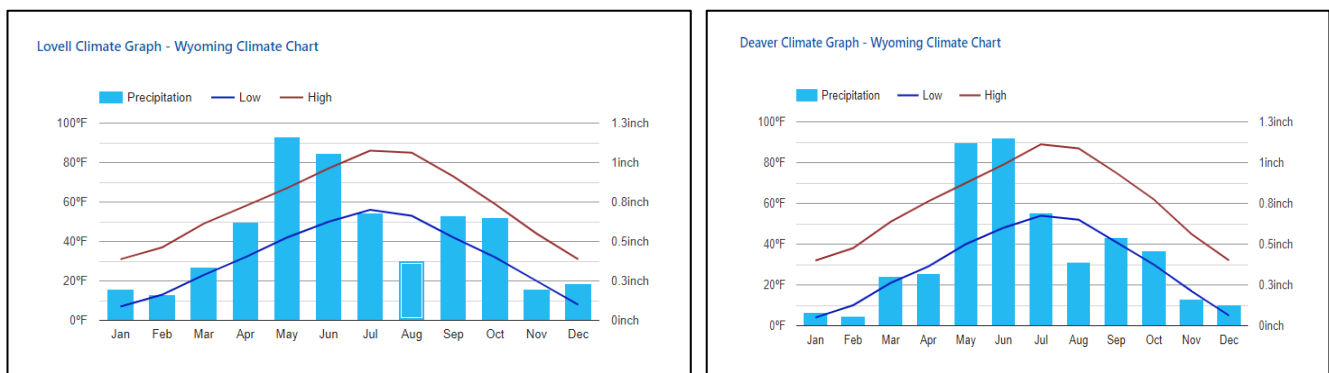
(d) SOs in Gyp Spring area.

Figures 6a-d: *Physaria pachyphylla* SOs that exhibit viable populations are overlain on aerial imagery (a, c) and topographic layers (b, d) to illustrate outcrops and contours.

rusty sandstone on top, underlain by brightly variegated bentonite claystone, with chert pebble conglomerate at the base. The Morrison has dully variegated claystone, modular limestone, and gray silty sandstone at the base. Only the latter is described as including a limestone layer.

4. Soil Relationships: Grady and O’Kane (2007) noted that *Physaria pachyphylla* “...is apparently limited to pinkish or reddish soils derived from limestone or a combination of limestone and diatomaceous earth”. Lesica (2022) described the habitat as “Stony soil derived from limestone or calcareous sandstone on exposed slopes, ridges; valleys.” High surface cover of gravel was consistently found in the surveys conducted by MTNHP and WYNDD botanists. In most places we referred to the surface as a gravel pavement in the absence of a soil profile development. The presence of gravel may be more consistent than the parent material (see substrates in **Photos 13-18**). At the Britton Spring site, *Physaria pachyphylla* was present on three different low ridges of different parent material and at its highest, was at the toeslope of a high ridge. The gravel at one of these sites consisted of marine fossils lying on the surface. At the Dry Creek and at a mid-valley segment of the Big Coulee sites, colluvial gravel with an admixture of parent material was found. The calcareous parent material is generally comprised of silt-sized particles, whether it breaks down to its finest texture or to coarse gravel. In many cases, the calcareous bedrock is exposed at the surface, covered by gravel, and has fractures that accumulate the fine-texture silt. Most settings with *Physaria pachyphylla* lack soil profile development, which generally indicates both low organic matter and nitrogen availability. Soils rich in calcareous carbonate may still have high water absorbency, although water availability is constrained by percolation and erosion conditions. The Dry Creek site and part of the Big Coulee site had rounded colluvial deposits and more soil profile development than other sites.
5. Regional Climate: The Pryor Mountain foothills and desert is affected by rain shadows, with mountains intercepting moisture-laden storm fronts, including the Big Horn Mountains to the east, and the Beartooth Mountains to the west. It is part of the Bighorn Basin, which is the lowest intermountain basin in Wyoming.

Measures of precipitation and temperature at the Lovell and Deaver meteorological monitoring stations in Wyoming were used to assess climate in the study area (USDI NOAA National Weather Service 2024a and 2024b; WRCC 2023). Average monthly climate conditions were schematically represented by juxtaposing the precipitation bar graphs with the temperature line graphs (**Figure 7a**). May and June months have peak precipitation, while July and August have peak temperatures (**Figure 7b**).



Figures 7a-b. Regional climate data for precipitation and temperature at the Lovell and Deaver meteorological stations in Wyoming (USDI NOAA – National Weather Service).

The stations at Lovell and Deaver are only about 22.5 kilometers (14 miles) apart yet differ in the amounts of precipitation and snowfall received. Climate conditions at Lovell are overall slightly wetter, which is likely due to their proximity to the Big Horn Mountains and Big Horn River (**Table 3**). This large range of minimum and maximum precipitation relative to the annual average suggests there is a high variation in precipitation between and within years, as well as over short distances (**Table 3**). This is particularly apparent from the past two years of data. Lovell had above-average precipitation in 2023 (21.29 centimeters (cm); 8.38 inches (in)) with almost half falling in June 3 (9.68 cm; 3.81 in) while Deaver had below average precipitation in 2022 and 2023 (WRCC 2023).

Table 3. Regional climate data for precipitation at the Lovell and Deaver meteorological monitoring stations in Wyoming (WRCC 2023).

Parameter	Lovell (1897-2012)	Deaver (1916-2016)
Average Annual Precipitation	16.87 cm; 6.64 in	13.82 cm; 5.44 in
Maximum Annual Precipitation	1940: 28.22 cm; 11.11 in	1964: 24.16 cm; 9.51 in
Minimum Annual Precipitation	1919: 6.32 cm; 2.49 in	1954: 5.84 cm; 2.30 in
Average Annual Snowfall	43.43 cm; 17.1 in	31.24 cm; 12.3 in

6. Local Microclimate: The exposed ground surface where *Physaria pachyphylla* grows has high evaporation rates. The gravelly surfaces and fractured bedrock of the habitat may enhance percolation and reduce runoff in otherwise erosion prone settings. At the scale of an individual plant, the dense silvery-gray hairs may be an adaptation that creates high reflectance, reducing evapotranspiration, and form a leaf surface where stomates can more efficiently regulate the exchange of water and gas (air).

F. Population Biology and Demography

Scientific research is needed to study the population biology and demographics of *Physaria pachyphylla*. The following information is based on professional experience and a general knowledge of *Physaria* species. An in-depth review of the literature on *Physaria* species and other close relatives was not carried out for this project but could result in additional information.

1. Life Span: The “typical” *Physaria pachyphylla* life cycle is that of a short-lived perennial. The time of germination is not known. The authors could not deduce from the fieldwork if plants germinate in spring or fall because we found no seedlings in June of 2023 or 2024.

The transition from a seedling to a vegetative plant is called establishment. It requires that the species draw from limited seed reserves to develop a taproot to reach subsurface moisture. Vegetative plants are comprised of a cluster of leaves that are often called a rosette. This just means that the leaves are arranged in radial symmetry and grow low to the ground. Vegetative plants were found at all occurrences in June.

Some short-lived perennial plant species can flower within two years. We saw some very small plants with flowers, but most likely they require at least three years to transition from a vegetative to flowering plant. If we assume it takes two or three years to go from a seedling to flowering stage then we think the average lifespan of the species may be 3 to 5 years. Field observations imply that plants become more branched and larger with age, and presumably the taproot gets wider and longer. We hypothesize that plants could live for 10 years. For seedlings that establish and make it to the vegetative plant stage, the average

may only be 3 or 4 years, so perhaps only 1 in 1,000 plants gets to a large size (**Photos 10 and 11**). If so, maximum lifespan is apt to be highly variable and much less important than average life span and key life history transitions.

We saw some vegetative plants that had inflorescences of the previous year, indicating that a flowering plant can revert to a vegetative one in a subsequent year. A minority of vegetative plants showed this reversal. We definitely saw flowering plants that had inflorescences of the previous year. An in-depth review of the *Physaria* literature and/or a longer-term study is needed to determine the number of consecutive years that a plant can flower. There are at least a few *Physaria* species that have a seed bank, meaning that seeds can persist below ground, waiting until favorable conditions to germinate.

2. Phenology: The species identification handout developed by O’Kane (2023) stated “Flowering June-July. Somewhat earlier dates expected” (**Appendix A**). We started fieldwork on 11 June 2023 and found that the species had completed or was close to finishing flowering. We had aimed to inventory sites in 2023 when *Physaria pachyphylla* was still in flower so as to enhance detection. We received reports from a visiting botanist who found *Physaria pachyphylla* had started flowering on May 18, 2023, at the type locality (Jennifer Lyman personal communication). We learned from moth researchers working at *Physaria pachyphylla* sites, that in 2021 plants were both in fruit and late flower stages on June 2nd at the lower elevational (about 4700 feet) Gyp Spring type locality and in flower and fruit on June 3rd at the higher elevation (about 5000 to 5200 feet) Demijohn Flats site (Marian Lyman personal communication). WESTECH staff surveyed sites at higher elevations ranging from 5,200 to 5,700 feet in 2024. They found *Physaria pachyphylla* plants either in flower or in both flower and fruit on June 8th. These observational records suggest that at lower elevations flowering may be finishing in early June, and fruiting may be starting in late May. At higher elevations, flowering may be extended into mid-June while fruiting may be starting in late May. It is likely that *Physaria pachyphylla* phenology may shift between years in response to major weather conditions.

Based upon field inventories, fruits predominantly dehisce by at least August or September, depending upon elevation, microsite conditions, and local weather patterns. WESTECH staff found populations in mid-August with either intact or dehiscent fruits, depending upon the site. Plants photographed by BLM staff in the Gyp Spring area showed fruits had completely dehiscent by September 20, 2020 (**Photos 12**).

3. Population Size and Condition: Field inventories found that *Physaria pachyphylla* plants tend to grow in dense clusters and at sparse densities within its habitat. Mapping population boundaries and estimating numbers was difficult because densities were unpredictable, and presence changed with terrain features. Counting plants was also a challenge because *Physaria pachyphylla* plants are small, less than 10 cm tall, with a silvery-green color that blends in with the substrate. Heavy rain can splatter their leaves with soil, and when dried contributes to their camouflage. In flower, plants are much easier to see from a greater distance, but more difficult to identify because flowers of many *Physaria* species look similar. In fruit the species is easier to identify, but difficult to spot at distances greater than 3-5 meters from view. Furthermore, there are many settings where *Physaria pachyphylla* grows in a low density or didn’t occupy what we thought was suitable habitat. In other words, within known habitat there is an uneven distribution of occupied places and gaps.

Population estimates prior to 2023 were non-existent or qualitative (common, infrequent, etc.) and in 2023 and 2024 were more quantitative. Surveyors working for MTNHP,

WYNDD, and WESTECH used a variety of tactics to count or estimate the number of *Physaria pachyphylla* plants depending upon the amount of land surveyed, aerial extent of plant cover, plant density, terrain features, and one's personal preference. The MTNHP and WYNDD botanists tallied plants as they encountered them in their survey and then extrapolated their numbers to the estimated area of habitat at a given location. In another situation, the number of plants in a specified area, such as a 10-foot radius, was extrapolated to a known area of occupied habitat. The WESTECH botanist and biologists also tallied plants, but in defined mine-related project boundaries; at some sites they extrapolated the numbers to an estimated area of habitat. Based upon the inventories, the number of *Physaria pachyphylla* plants counted or estimated has been compiled for each MTNHP SO and WYNDD OBS polygon (**Table 4**). The 25 MTNHP SOs and 9 WYNDD OBS polygons cover approximately, 2,130 acres. Plants are not uniformly present throughout each discrete polygon and census surveys were not conducted. Based on the portions of these polygons surveyed, 6,017 plants were counted, and the population was estimated to range between 7,837 to 12,493 individuals (**Table 4**).

4. Reproductive Biology

- a. *Type of Reproduction*: *Physaria pachyphylla* reproduces entirely from seed. In the Mustard Family, Brassicaceae, flowers are relatively uniform within genera and little-differentiated when compared to the highly differentiated fruits (Rollins 1993). The unspecialized flowers attract generalist pollinators as pollen vectors, which in this sparsely vegetated habitat might enhance the reliability of pollination (Rollins 1993). Our observations indicate that fecundity varies greatly with growth form. At maturity, *Physaria pachyphylla* produces up to 8 seeds per fruit, with few-many fruits per inflorescence, and 1-many inflorescences per plant (O'Kane in FNA 2010).
- b. *Pollination Biology*: Outcrossing pollination by insects is a required method of fertilization for successful reproduction of other *Physaria* species (Clark 2013; Claerbout et al. 2007). Insects, including ground-nesting bees, have been documented as pollinators for other *Physaria* species (Meier et al. 2011). The Montana Moth Project, led by the Northern Rockies Research and Educational Services (NRRES), conducts field surveys to bring forth information on moth species diversity, abundance, and ecology in Montana. At the Demijohn Flats populations, pollen from *Physaria pachyphylla* was detected on 5 moths of 4 different species, including the *Protophygia enalaga* moth, using DNA analysis. This is evidence that moths visit *Physaria pachyphylla* and transport its pollen (NRRES 2021, Marian Lyman personal communication 2023).
- c. *Seed Dispersal and Biology*: There are no known specialized structures for dispersing seeds (O'Kane 2010). Seeds are not winged to catch wind (O'Kane 2010). The globose- or ellipsoid-shaped fruit is composed of a single valve from which seeds are freely released without the aid of wind (as opposed to two-valved fruits) (O'Kane 2010). This implies that seeds do not disperse far from the parent plant. However, it is possible that their light weight and round shape could facilitate being transported by strong winds at the ground level. Some *Physaria* species have mucilaginous seeds, which upon wetting become glued to the soil particles. In a little field test with seeds collected in 2024, Scott Mincemoyer found *Physaria pachyphylla* seeds to be partially mucilaginous while *Physaria spatulata* seeds showed no signs of mucilage (USDI FWS 2024c). The uneven surface and prevalence of gravel in its habitat may help capture dispersing seeds and keep them nearer to their parent plant.

Table 4. The number of *Physaria pachyphylla* plants counted and the lower-end and higher-end estimates of population size for the portions of MTNHP SOs and WYNDD Observations surveyed.

MT SO-ID or WY OBS Name ¹	MT SO or WY OBS Area (acre)	PLANT COUNT	LOWER-END POPULATION ESTIMATE OR COUNT ²	HIGHER-END POPULATION ESTIMATE ^{2,3}	COMMENT
2034123	0.3	1	1	2	Found on BLM AIM plot in 2021.
2307112	10.87	20	40	80	
2307113	8.77	113	200	400	
2307117	0.3	1	1	2	Presence found.
2307120	0.6	10	10	11	
2307336	0.3	1	1	2	Presence found.
2374172	<0.01	5	5	6	
2374183	0.02	1	1	2	Presence found.
2374184	<0.01	7	7	8	
5002328	134.1	1,294	1,294	1,295	BLM staff recorded 1,294 GPS points where <i>Physaria pachyphylla</i> was present. Observers noted that often multiple individuals were found at a single GPS point.
5002329	77.97	190	190	191	Counts based only on 2023 and 2024 years.
5003313	2.33	459	500	1,000	
5003314	1142.68	1,305	2,000	3,000	Counts and estimates for locations in MT and WY.
5003315	348.71	59	145	271	Counts and estimates for locations in MT and WY.
5003319	26.36	32	35	41	Count tally stated "about" 32 plants.
5003320	14.57	14	24	48	
5003321	29.88	39	74	144	
5003370	16.78	258	258	259	
5003371	53.08	12	12	26	
5003372	73.74	85	85	86	
5003373	0.47	14	14	15	
5003374	0.54	11	11	12	
5003375	0.18	8	8	9	
5003376	2.28	101	101	102	count stated "over" 100 plants.
5003377	5.91	230	230	231	
Britton Spring	91.8	849	1400	2900	Almost all in Wyoming
Dry Creek	0.1	26	40	50	Wyoming
Big Coulee	49.1	818	1000	2000	Wyoming
Sykes Ridge South	37.9	54	150	300	Almost all in Wyoming.
TOTAL	2,129.64	6,017	7,837	12,493	Mapping and plant counts for some MT SO and WY OBS Names may overlap.

¹ Montana assigns a unique identifier to the SO (SO-ID). Use Appendix B to crosswalk Montana SO-IDs and Wyoming Observation (OBS) Names with mapped locations.

² Plant counts were used to estimate population size to the area of habitat perceived as suitable during the inventory. Plant counts are not an estimate of population size for the given SO.

³ **Red numbers** are one count more than the lower estimated or counted population size. In these situations, information was not available to estimate an accurate maximum population size.

G. Population Ecology

1. General Summary: In general, *Physaria pachyphylla* plants appear randomly distributed in either clusters or as widely spaced individuals within suitable habitat. Signs of direct biological interactions between individuals or with other species were not observed by the authors.
2. Colonization: We found *Physaria pachyphylla* plants to occupy native, undisturbed habitat. However, WESTECH staff surveyed 33 mine features at 7 Defense-Related Uranium Mines (DRUM; abandoned mines) that were active between the years of 1947 and 1970 (WESTECH 2024). Of the 33 mine features *Physaria pachyphylla* was found at 15 (refer to Section V. A-1b) (WESTECH 2024). The level of ‘disturbance area’ surveyed at these features ranged from “not appearing altered” to “small excavations” and disturbed places, such as two-track roads (Beaver and Gunther personal communications). Although disturbance was found, these abandoned mines still had intact soils and decades of environmental rest. Further, the MT/Dakotas BLM restricted public ATV/UTV access to most of the 15 mine features using fences and signage (Beaver and Gunther personal communications). The surveys indicated that under these described conditions, *Physaria pachyphylla* can colonize previously disturbed ground and establish, at least temporarily on roadbeds and where seeds wash into it (Mincemoyer personal communication).
3. Competition: The sparse vegetation of species’ habitat indicates that it favors low-competition settings. We found *Physaria pachyphylla* growing in small clusters with plants often spaced apart from their neighbor. We also found many plants in more isolated settings within its habitat. On the abandoned mine sites observed by WESTECH staff, *Physaria pachyphylla* was found growing widely separated from other plants 60-70% of the time (Gunther personal communication).

However, there were occasional observations of *Physaria pachyphylla* individuals rooted in the mat or litter of another plant species. If a species requires the microhabitat or dead plant material of another species, then the latter is a “nurse plant” facilitating its establishment, growth, or key life history stage. *Physaria carinata*, a relative that is endemic to southwest Montana and adjacent Idaho is also a calciphile of bare habitat (Lesica et al. 2022). *Physaria carinata* was shown to have dual “competition/facilitation” relations with the dominant bunchgrass species in its habitat that were conditioned upon climate (temperature and precipitation) (Greenlee and Callaway 1996). The research found that for *Physaria carinata* the long-term effects of the bunchgrass providing temporal shade (facilitation) outweighed those of interference (competition for water, light, and nutrients) at more xeric sites where abiotic stress is higher (Greenlee and Callaway 1996). This may be an appropriate model for *Physaria pachyphylla* and its associated species, in which both relationships are possible. However, the infrequency of *Physaria pachyphylla* growing within the foliage of other plants does indicate that interference is more important than facilitation.

4. Herbivory: The eastern portion of species’ distribution, including at least Britton Spring and Sykes Ridge South lies within the Pryor Mountains Wild Horse Range where horse use is present, cattle use is absent, and vehicle access is limited to roadways. We did not find signs of direct browsing, grazing, or trampling of *Physaria pachyphylla* plants. Some trails were observed in occupied habitat. It grows low to the ground and is unlikely to be grazed by cattle and wild horses or browsed by big game. The dense hair surface and volatile oils may further deter herbivory.

5. Other Plant-Animal Interactions: We noted a very low frequency of galls formed on *Physaria pachyphylla* plants and very uncommon signs of what appeared to be a rust fungus.
6. Hybridization: During 2023 and 2024, specimens of *Physaria pachyphylla* and *Physaria spatulata* that exhibited a range of phenology and growth forms were collected. Specimens and many photographed plants were identified by O’Kane, which proved that the distributions of *Physaria pachyphylla* and *Physaria spatulata* overlap in the Pryor Mountain Desert. At least three specimens and two photographed plants showed characteristics described by O’Kane in 2023 and 2024 as “possible introgression from *Physaria spatulata*”, indicating possible hybridization. In 2023, MTNHP and WYNDD botanists found isolated individuals of *Physaria* that were pegged as “oddballs” and photographed but did not census them during fieldwork were present at Gyp Spring and Helt Road. Of the 7 abandoned mine sites surveyed by WESTECH botanist and biologists, *P. spatulata* was present at 1 site and intermediary plants were found at 2 other sites. Intermediary specimens may have a different combination of characteristics such as some sigmoid pedicels, inflorescence that is not subumbellate, and basal leaves that are somewhat spatulate.

In light of similarities between *Physaria pachyphylla* and *P. spatulata*, and at least low incidence of hybridization, we recommend using the identification handout (**Appendix A**) in combination with specimen review before conducting fieldwork. Where populations are large, we recommend collecting and properly pressing voucher specimens.

H. Land Ownership

Physaria pachyphylla is known to occur on federal and state land in Montana and on federal land in Wyoming. Federal lands are managed by the MT/Dakotas BLM, Billings Field Office, Wyoming BLM State Office, and the National Park Service, Bighorn Canyon National Recreational Area. State land is managed by the Montana Department of Natural Resources and Conservation, Montana State Trust Lands Management Division. *Physaria pachyphylla* may also occur on private land, but we do not know of any surveys conducted on private lands.

Of the 25 MTNHP SOs in Montana, 23 are entirely and 2 are partially on lands managed by the MT/Dakotas BLM (**Figure 8**). Many of the SOs intersect with special designated administrative units, including the Pryor Mountain Wilderness Study area, Pryor Mountain Wild Horse Range, and Defense-Related Uranium Mine sites. For two MTNHP SOs land ownership also includes either the Montana State Trust Lands or Bighorn Canyon National Recreational Area (**Figure 8**). Of the 9 WYNDD Observation polygons in Wyoming, all are found on lands administered by the Wyoming BLM State Office (**Figure 8**).

Physaria pachyphylla
Occurrences*

- MTNHP Species Occurrence
- WYNDD Observation
- Draft Element Occurrence

* as mapped by MTNHP

Land Ownership

- Montana State Lands
- Wyoming State Lands
- National Park Service
- Crow Reservation
- US Bureau of Land Management
- US Bureau of Reclamation
- US Forest Service
- Private/Other
- Pryor Mtn. Wild Horse Range
- MT-WY State Boundary

Map Labels: Hillsboro, Levitt Creek, Gypsum Creek, Crooked Creek, 4915 ft, 4614 ft, SYKES MOUNTAIN, Bighorn Canyon, North Big Horn County Airport, Cowley, County Line, Bighorn Lake.

Inset Map: Bighorn Canyon National Recreation Area, MONTANA, WYOMING.

Scale: 0 1.5 3 Kilometers

IV. CONSERVATION CONSIDERATIONS

A. Current and Potential Threats to *Physaria pachyphylla* Occurrences

Information on current and potential threats to *Physaria pachyphylla* plants and their habitat was compiled from the MTNHP botany database, agencies, literature, and field inventories. The following threats have been identified as factors that can, if not properly mitigated or managed, put *Physaria pachyphylla* populations at-risk of state extirpation or global extinction in Montana and Wyoming.

1. Mining: Mining and its associated activities can directly and indirectly harm *Physaria pachyphylla* plants and habitat. Potential negative impacts include direct removal and trampling of plants. Potential indirect negative impacts come from ground-disturbing activities and non-native plant colonization. Ground-disturbing activities can result in soil erosion, soil compaction, and other changes to soil and water properties necessary for the viability of *Physaria pachyphylla* populations. Soils in the Chugwater Formation are known to be very susceptible to erosion. Non-native species that colonize habitat are likely to out-compete *Physaria pachyphylla* for water and nutrients and/or modify the natural habitat. Mining related activities have the potential to introduce and/or favor conditions for non-native species through multiple vectors (refer to Section IV. A. 2, *Non-native Species*).

The potential for direct and indirect impacts to *Physaria pachyphylla* from proposed mining activities currently exists, as follows:

- a. *Gypsum Mining*: Gypsum is a common mineral found in the Chugwater Formation in Montana and in the Chugwater Group in Wyoming. *Physaria pachyphylla* populations and habitat intersect or overlap with the Chugwater Formation. A recent proposal for gypsum exploration began in 2020, and is on-going (MT/Dakotas BLM 2020; Helena Independent Record 2021). Gypsum exploration has been proposed on BLM public lands, including the Pryor Foothills Research Natural Area (RNA)/Area of Critical Environmental Concern (ACEC) where one of the largest *Physaria pachyphylla* population and numerous other State of Montana SOC and PSOC plants occur.
- b. *Abandoned Defense-Related Uranium Mines (DRUM) sites*: Scattered across the known habitat for *Physaria pachyphylla* are 33 existing but abandoned DRUM sites (WESTECH 2024). Associated with these abandoned DRUM features are mine adits, shafts, trenches, high walls, open pits, unstable structures, and other areas of subsidence that could present a danger to humans and wildlife (WESTECH 2024). The MT/Dakotas BLM Billings Field Office, in coordination with the Department of Energy and bat Conservation International is planning to safeguard these DRUM sites in 2025 (WESTECH 2024). Typical methods to safeguard these mines include installing polyurethane foam, cable nets or bat gates across adits and shafts, or back-filling features with local materials (WESTECH 2024).
- c. *Gravel Quarries*: There are abandoned gravel quarries within the range of *Physaria pachyphylla*. The western part of the Dry Creek occurrence in Wyoming appeared to have been a small undeveloped roadside gravel quarry. An active limestone quarry occurs outside of this study area. It is unknown if they signify potential uses.

2. Non-native Species: Non-native plant species that colonize habitat are likely to out-compete *Physaria pachyphylla* for water and nutrients and/or modify the natural habitat. Although some non-native plant species may be benign, many, including State or County designated noxious weeds, pose significant threats to *Physaria pachyphylla* and other native plants. Herbicide applications that are not appropriately applied with the correct chemical, concentration, timing, method, and equipment or under the proper environmental conditions or following best management practices and regulations can negatively impact *Physaria pachyphylla* and soil properties. Non-native plant species can colonize the native habitat through many vectors, including:
 - Natural dispersal from populations that are in vicinity and not controlled
 - Plant materials carried by equipment, footwear, and clothing
 - As a contaminant in desirable or native seed sources
 - Ground-disturbing activities that modify the habitat
 - Other anthropogenic sources

The arid landscape in which *Physaria pachyphylla* occurs is predominantly native, intact habitat. However, Cheatgrass (*Bromus tectorum*) and African Mustard (*Malcolmia africana*; syn. *Strigosella africana*) are present in scattered locations in the Pryor Mountain Desert of Montana. Cheatgrass occurs along some roads, transmission lines, and slopes and populations are adjacent to at least some *Physaria pachyphylla* SOs (MTNHP 2024a), including the large *Physaria pachyphylla* population located at Gyp Spring. African Mustard occurs along some roads in the Gyp Spring area, is sporadically found on undisturbed slopes, and is documented in at least 3 *Physaria pachyphylla* SOs (MTNHP 2024a and 2025). These non-native annual plants have the potential to negatively impact *Physaria pachyphylla* populations through direct competition for soil, water, and nutrient resources. In addition, Cheatgrass has the ability to change a site's ecology and fire regime (MTNHP 2024b).

Field inventories in 2023 and 2024 also found Cheatgrass and African Mustard in Wyoming. Along the northwest edge of the Britton Spring observation there is a very serious invasion of Cheatgrass and African Mustard. These annual exotics border occupied *Physaria pachyphylla* habitat; a fence separates the occupied habitat from the high density weeds in the Britton Spring administrative compound. At the Dry Creek location, Cheatgrass is present and has invaded into occupied habitat.

3. Off-road Recreation: Off-road vehicle (ORV) use can directly trample *Physaria pachyphylla* plants, resulting in death and/or damage. Potential indirect impacts from ORV use can result in creating soil erosion, soil compaction, altering the microtopography of the soil or landscape, and providing vectors for non-native plant establishment (refer to Section IV. A. 2, *Non-native Species*).

Recreational ORV use commonly occurs further north in the Pryor Mountains. At least some recreational ORV use occurs in vicinity of *Physaria pachyphylla* sites. Other ORV use for management purposes occurs within the areas occupied by *Physaria pachyphylla*. We observed that ORV use in vicinity of *Physaria pachyphylla* generally follows existing 2-track roads and trails, which greatly minimizes the potential for negative impacts. We observed that where *Physaria pachyphylla* plants occur at discrete scenic overlook points along canyon rims, ORV use diverged from the 2-track road into occupied habitat. This was noted at Crooked Creek and at the north end of the primary Gyp Spring ridge. At the abandoned mines, WESTECH staff found overall that off-road vehicle use did not seem to negatively impact *Physaria pachyphylla* under the current conditions (WESTECH 2024).

4. Lack of Federal Protection: The Pryor Foothill RNA/ACEC occurs in the Gyp Spring area of Montana and covers approximately 2,606 acres. It was nominated in 2009. The most recent Billings Field Office Approved Resource Management Plan listed the Pryor Foothill RNA/ACEC as an area “recommended for withdrawal from mineral entry and all locatable mineral withdrawal” (BLM 2015). The BLM management goals for this RNA/ACEC are to protect a large concentration of BLM special status plant species, unique plant communities, and significant historic and cultural values in the Gyp Spring area (MT/Dakotas BLM 2015). Permitting activity is not ruled out within or adjoining designated ACECs but is decided on a case-by-case basis. This RNA/ACEC contains a very large concentration of *Physaria pachyphylla* and numerous other Montana SOC plant species (MT/Dakotas BLM 2015). To date the U.S. Congress has not given final approval for the designation of and change management recommendations for the Pryor Foothill RNA/ACEC (MT/Dakotas BLM 2015). The lack of this federal designation contributes to factors that puts *Physaria pachyphylla* and other Montana SOC at risk of state extirpation and/or global extinction.

B. Other Conservation Considerations

Special Management Designations: Within Montana the MT/Dakotas BLM manage at least two areas with a special management designation:

- Pryor Foothill RNA/ACEC. Refer to Section IV. A. 4, *Lack of Federal Protection*.
- Pryor Mountain Wild Horse Range. It is one of only four designated wild horse and burro ranges in the country. It is managed principally, but not exclusively, for wild horses. A portion of the *Physaria pachyphylla* distribution occurs within this range.

C. Recommended Conservation Actions

Implementing conservation practices and appropriate management techniques can further the persistence, and hence the viability, of *Physaria pachyphylla*. The following conservation actions are provided for BLM’s consideration relative to *Physaria pachyphylla*:

1. Support the MT/Dakotas BLM’s nomination to create a formal designation for the Pryor Foothill RNA/ACEC and withdrawal from mineral entry and all locatable mineral withdrawal.
2. Develop and implement an integrated vegetation management approach to address non-native species, especially for Cheatgrass and African mustard in the Pryor Mountain dessert area. An integrated vegetation management approach provides the best long-term control, and requires that land-use objectives and a desired plant community be identified (Shelly et al. *in* Sheley and Petroff 1999).
3. Prevent the establishment and/or spread of non-native, noxious, and invasive species, especially for Cheatgrass and African Mustard:
 - Learn how to accurately identify Cheatgrass, African Mustard, and other noxious or invasive species to detect occurrences and know where to implement control methods.
 - Prevent vehicles from driving through and animals from grazing within infested areas.
 - Thoroughly wash the undercarriage of vehicles, wheels, and other equipment in a designated area before moving to non-infested areas.
 - Frequently monitor for new non-native plants, and when found implement effective control methods.
 - Contribute to or develop educational campaigns to help eradicate or reduce Cheatgrass,

African Mustard, and other noxious and invasive species in the region.

4. Mis-use and incorrect timing of herbicide applications used to control annual non-native, noxious, and other invasive plants can pose a risk to *Physaria pachyphylla*. Deleterious risks to native plants and pollinators can be reduced by ensuring that licensed applicators are used and follow best management practices and local regulations. Herbicide applications should be applied with spot treatments using the appropriate chemical type and concentration, application time and method, and under proper environmental conditions to avoid chemical drift or over-spraying.
5. Support, retain, or even expand restricted access by the BLM in areas where *Physaria pachyphylla* is documented. Signage, fencing, and/or physical barriers installed by the BLM apparently seem to help reduce loss from off-road vehicle use.
6. Where mining activities are proposed, continue to conduct surveys by qualified botanists and biologists to document presence/absence and monitor populations. Where there is the potential for negative impacts from proposed project, strive first for avoidance. Where avoidance is not possible, strive for strategies that mitigate negative impacts to the plants, habitat, and soils.
7. Ground-disturbing activities in vicinity of abandoned mines should be kept to the smallest area practicable, avoid locations with *Physaria pachyphylla*, and should be reclaimed as soon as is practical. All areas should be kept in neat condition by promptly cleaning up any project related spills, litter, garbage, and other materials.

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Appendix A

Physaria pachyphylla & *P. spatulata* technical identification handout

Physaria pachyphylla in Montana and Wyoming: Field Surveys and Status
Assessment, 1983 to 2024

DISTINGUISHING *PHYSARIA PACHYPHYLLA* FROM *P. SPATULATA*

Compiled by S. L. O'Kane, Jr.

1a. Fruiting pedicels curved; basal leaves (when fresh) nearly 1 mm thick, blades cupped; style 1–3 mm, shorter than mature fruit; fruits globose to ellipsoid, with slight apical constriction, valves densely covered by trichomes; Pryor Mtn. desert of south-central Montana and north-central Wyoming . . . *Physaria pachyphylla*

1b. Fruiting pedicels moderately to sharply sigmoid; basal leaves not thickened, blades flat; style 2.5–6 mm, usually $\pm$ equal in length to mature fruit; fruits lanceolate to orbicular, apex usually strongly narrowed, valves sparsely covered by trichomes; plants widespread, from western Nebraska and Wyoming northward to southern Alberta and Saskatchewan . . . *Physaria spatulata*

Characters bolded below are especially helpful in distinguishing these species. All characters are variable and one should make species determinations based on several. A strong basal rosette of thick, cupped, and densely pubescent leaves coupled with other characters is the best indicator for *Physaria pachyphylla*. When describing fruiting pedicels be sure to examine ones that are fully mature.

Physaria pachyphylla O'Kane & Grady

Thickleaf bladderpod

Perennials; **caudex usually simple, rarely branched, moderate to large in size; loosely mounded from a strong basal rosette of leaves; densely pubescent, the leaves, therefore, silver or silver-pale green,** trichomes sessile, 5-rayed, rays bifurcate, slightly fused near base of main rays, tuberculate throughout, less over umbo. Stems several from base, decumbent to prostrate, well-exserted beyond basal leaves, 0.2–0.5 dm. **Basal leaves: petiole differentiated from blade; blade slightly cupped, leathery, nearly 1 mm thick, oblanceolate to orbicular, 1.2–2 cm, margins entire, apex acute.** Cauline leaves: blade spatulate. **Racemes dense, subumbellate, exceeding the leaves or sometimes $\pm$ equal to them. Fruiting pedicels ascending, curved, 5–7 mm, less than 2 times longer than fruits.** Flowers: sepals pale yellow, elliptic to oblong, 3.5–4.0 mm, median pair somewhat thickened apically, cucullate; **petals lingulate, 5–6 mm.** **Fruits globose or ellipsoid, slightly inflated with slight apical, latiseptate compression, 3–6 mm; valves densely pubescent, trichomes closely appressed; ovules 8 per ovary; style 1–3 mm, shorter than mature fruit.** Seeds plump..

Flowering June–July. Somewhat earlier dates expected.

Habitat: Barren areas of mixed white, pink, or reddish limestone and gypsum. According to Patrick Alexander (pers. comm.), **all known populations occur in or near the contact between the Chugwater Formation and the Gypsum Spring Formation (apparently called the Piper Formation in adjacent Montana)**

Elevation: 1300–1600 m / 4265–5250 ft. Somewhat higher elevations to be expected.

Physaria spatulata (Rydb.) Grady & O'Kane

Spatula-leaf bladderpod

Perennials; **caudex simple, relatively small; basal rosette weak to nearly absent; sparsely to moderately pubescent and leaves, therefore, green,** trichomes 4- or 5-rayed, rays furcate or bifurcate, not fused, (tuberculate). Stems simple from base, erect to decumbent, well-exserted beyond basal leaves, loosely spreading, 0.3–1.2 dm. **Basal leaves erect to prostrate, petiole distinct from blade; blade (inner) spatulate to oblanceolate, or (outer) oblanceolate or orbicular, 1.5–4 cm, margins entire, rarely folded.** Cauline leaves: blade spatulate, distinctly different from basal. **Racemes moderately dense, exceeding the leaves, often greatly so, 6–20-flowered. Fruiting pedicels strongly sigmoid at maturity, 10–20 mm, about 2 times longer than fruits.** Flowers: sepals pale yellow, elliptic, 3.5–5 mm; **petals lingulate, 6–9 mm. Fruits lanceolate or orbicular, slightly inflated, (2.5–)3–6 mm, apex usually strongly latiseptate, valves pubescent, trichomes sparse and closely appressed to surface; ovules 4–8 per ovary; style 2.5–6 mm, usually $\pm$ equal in length to mature fruit.** Seeds plump.

Flowering May–early July.

Habitat: Grasslands, subalpine meadows, sagebrush, scattered pines, fell fields, calcareous (sometimes alkaline) substrates

Elevation: 900–2900 m / 2950–9675 ft.

Physaria pachyphylla



Physaria spatulata



Appendix B

MAPS: 2024 Montana SOs and Wyoming Sites for Physaria pachyphylla

*Physaria pachyphylla in Montana and Wyoming: Field Surveys and Status
Assessment, 1983 to 2024*

Figure B-1. Index to maps displaying, at a smaller scale, the 25 MTNHP Species Occurrences (SOs) and 9 WYNDD observations for *Physaria pachyphylla*.

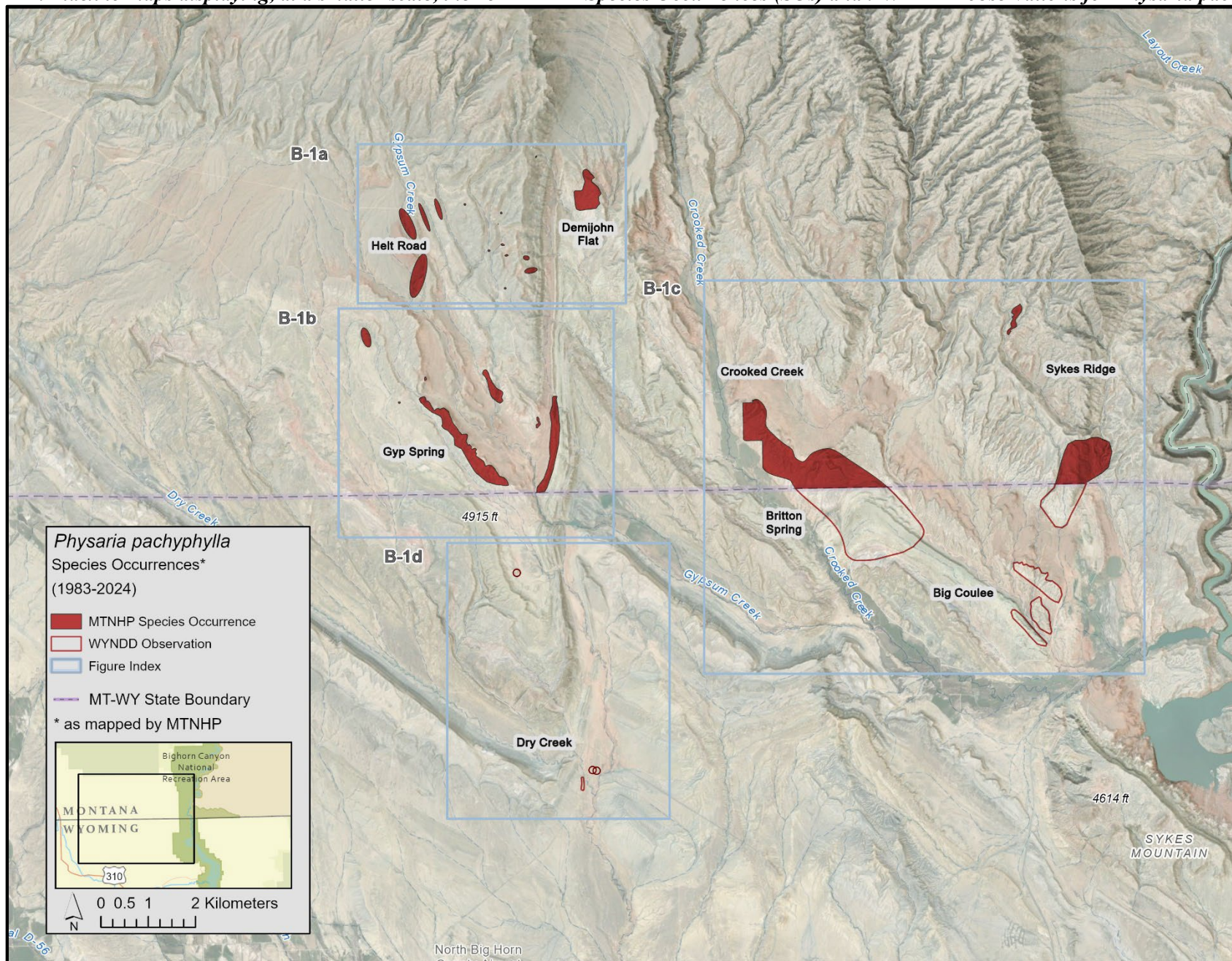


Figure B-1a. Map displaying, at a smaller scale, a selection of MTNHP SOs for *Physaria pachyphylla*.

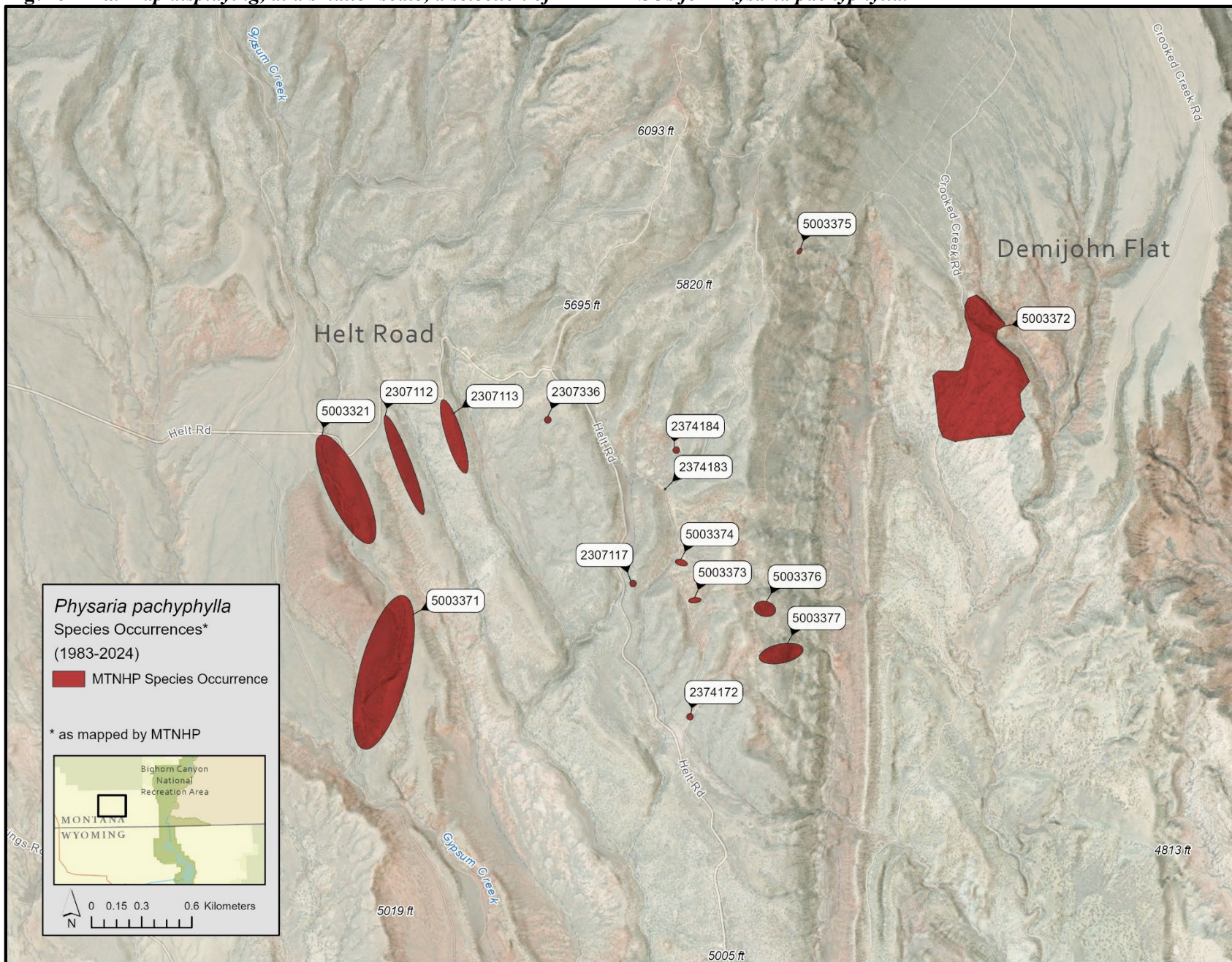


Figure B-1b. Map displaying, at a smaller scale, a selection of MTNHP SOs for *Physaria pachyphylla*.

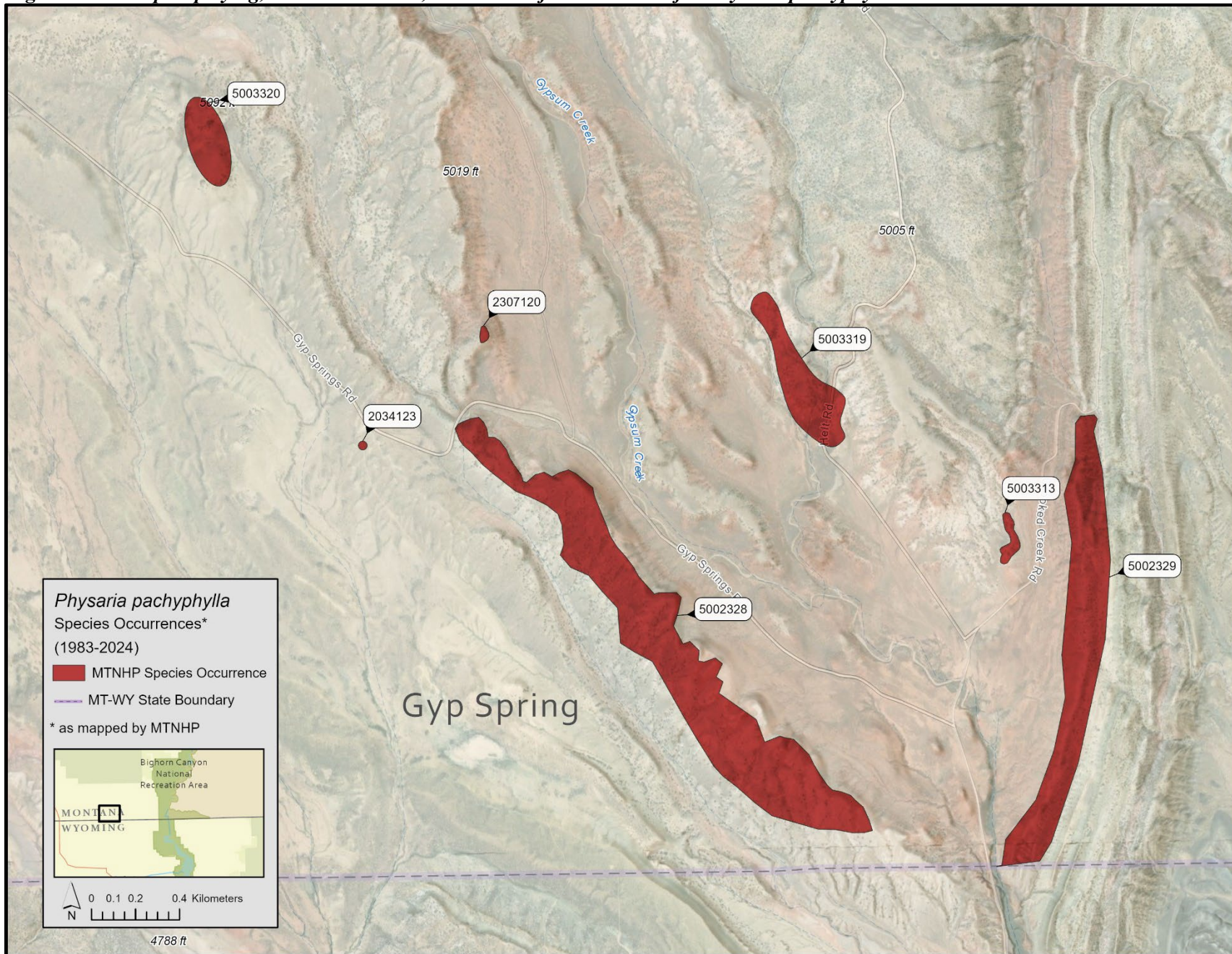


Figure B-1c. Map displaying, at a smaller scale, a selection of MTNHP SOs and WYNDD observations for *Physaria pachyphylla*.

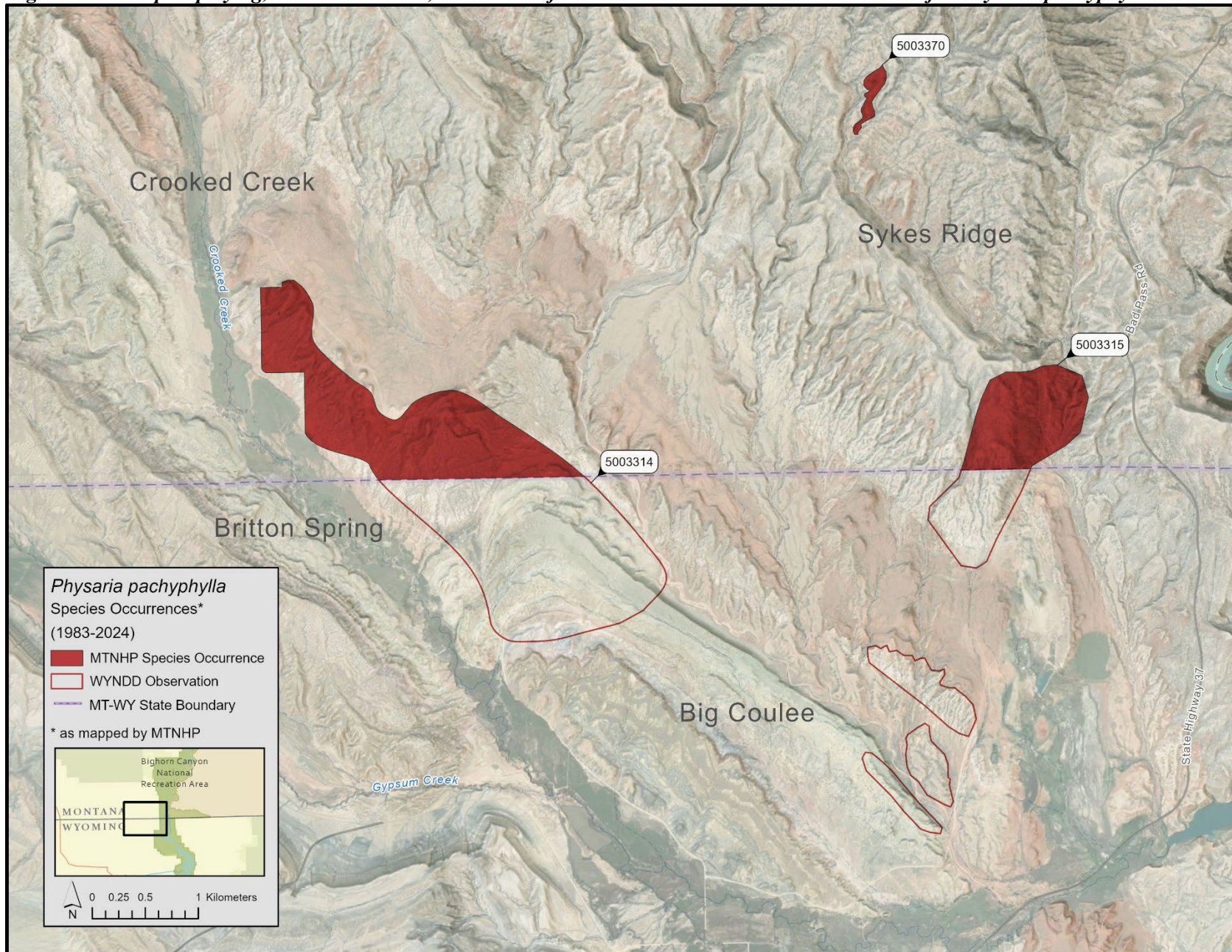


Figure B-1d. Map displaying, at a smaller scale, a selection of WYNDD observations for *Physaria pachyphylla*.

